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SOME OBSERVATIONS CONCERNING WOOD PIPE[1]

By J. W. Ledoux[2]

HISTORY

As a conduit for water, wood pipe was used before the Christian era, and up to within two centuries ago, with the exception of lead, it was the only pipe in existence, except for large gravity conduits and aqueducts where masonry was in use. The first wood pipes used consisted of logs with holes bored through the center, the joints being made by shaving one end to a taper to fit the inside of the next length. This type with modifications remained in use for centuries in European countries. London had several hundred miles of wood pipe, 400 miles of which were laid in 1613. It was its sole means of water supply for over two hundred years, and portions of the original lines unearthed in modern excavations have been found sound and solid. These pipes were "elm pump logs." It is stated that in 1862 some of these pipes were taken up after being in the ground 249 years, and found to be in good condition. Constantinople received its entire water supply through bored wood pipe for more than two centuries, and part of the city is still supplied in the same way. Philadelphia, New York, Boston and

[1] Presented before the Philadelphia Covention, May 17, 1922.

[2] Consulting Engineer, Philadelphia, Pa.

many other cities obtained their first supply of water through wood pipe, and some still retain this original wood pipe. In 1798 Aaron Burr organized the Manhattan Company and supplied residents in New York City with water through wooden pipes. The Water Company continued the service until 1842. Within recent years some of these old pipes have been dug out, and it is stated that the wood was found in a perfect state of preservation. In Philadelphia the wooden pipes were laid in 1799. They were made of oak logs 3 feet in diameter, rough dressed on the outside and with a bore ranging from 6 to 12 inches. Some consisted of spruce or pine logs bored out, mortise and tenon at ends with wrought iron bands fastened around each end. A great deal of it was in continuous use until 1844. Many of these pipes when dug up were found to be in good condition, although the iron bands which were used to make the sections were rusted away.

Boston, Massachusetts, built the first public water supply in America in 1652. The mains consisted of wood pipe, which were largely replaced with wood again in 1796. They were mostly taken up in 1848 and cast iron pipe susbstituted.

The above facts simply corroborate what is common knowledge, that wood pipe, constantly buried in the ground or kept saturated with water, has an indefinitely long life. It is true also that wood in a dry place is practically indestructible; on the other hand when the unpainted or uncoated material is subjected to alternate wet and dry and exposed to the air, the best wood obtainable will seldom last longer than twelve years, but a live tree of the same material will last several hundred years. All these facts show that the elements of destruction can be warded off and overcome.

Nearly seventy years ago a new method was developed for making wood pipe. This consisted of sawing the wood into narrow wedge shaped staves and forming them into a hollow cylinder, the longitudinal joints being radial. One end of the cylinder was formed into a tenon; the other end into a mortise, and so tapered that the sections of pipe so formed could be driven together making a continuous pipe. The staves were forced together and kept in place with iron wire or flat bands wound around the surface and frequently stapled or nailed in place.

A modification of this form omitted the mortise and tenon but provides a short constructed sleeve to form the transverse joint.

Still a later modification was the continuous wood stave pipe where dove-tailed staves of random lengths were formed into a pipe in the field and held together by hoops, or rods, having screw connections. The end joints of the staves were made tight by metal strips fitted into a sawed slit. This is known as the continuous wood stave pipe, and is very popular in large sizes, especially in the western country where redwood and Oregon fir woods are used. All these have almost completely superseded the bored lugs of the ancients.

The wood pipe industry is much more extensive than is commonly realized, and there are a number of concerns who have been for many years doing a large business. It would probably be conservative to say that there are installed during each year at least five hundred miles of wood pipe in various parts of the United States by the various companies engaged in the business. They are made in all sizes from 4-inch to 60-inch, and in some cases for large conduits and flumes as high as 12 or 13 feet in diameter and for pressures from zero to 150 pounds.

It may be stated in passing that nearly all the prominent wood pipe manufacturers are equipped for making either continuous or machine banded pipe, although some of the western companies make a specialty of large diameter redwood and fir continuous wood stave pipe. Western redwood and fir trees grow to large sizes and it is easy to obtain from them staves of any length, free from knots or other imperfections, which is impossible with the commonly used eastern pines and other woods.

For some years back the wood pipe companies have realized that in many situations the life of the wood could be very materially increased by creosoting, and I learn from some of the companies that about half of their business consists in creosoted pipe, and they say that this will give an average of double life of the untreated wood. However, in the majority of situations the life of wood pipe is dependent upon the life of the steel rods or bands.

The two main features which make the use of wood pipe attractive are low initial cost and constantly high carrying capacity.

A fair comparison of the cost installed of wood and cast iron pipe based on 65 pounds working pressure and New York delivery is as follows:

TABLE 1

NOMINAL PIPE DIAMETER	MACHINE BANDED WOOD PIPE		CONTINUOUS WOOD PIPE	CAST IRON PIPE AT $44 PER TON FOB NEW YORK
	Pine	Redwood	Redwood	
inches	per foot	per foot	per foot	per foot
6	$0.96			$1.26
12	1.49			2.69
20	2.29	$3.70	$3.4	5.21
24	2.89	4.84	4.19	6.71
30	4.13		5.27	9.13
36			6.35	12.02
48			9.50	18.90

All these prices are based on hauling taken at $2 per ton and trenching taken at the same price for the same size pipe. If we consider 20 and 24-inch sizes, we have:

TABLE 2

ITEMS	20-INCH	24-INCH
Machine banded pine	$2.69	$2.89
Machine banded fir	3.27	4.31
Machine banded redwood	3.70	4.84
Continuous redwood	3.43	4.19
Continuous fir	2.92	3.58

In the above prices, trenching is taken per lineal foot as follows:

6-INCH	12-INCH	20-INCH	24-INCH	30-INCH	36-INCH	48-INCH
$0.37	$0.52	0.78	$1.00	$1.15	$1.40	$2.00

The following weights of pipe are taken in pounds per lineal feet:

TABLE 3

ITEMS	6-INCH	12-INCH	20-INCH	24-INCH	30-INCH	36-INCH	48-INCH
Machine banded pine	15	22	38	49	85		
Machine banded fir			37	40			
Continuous redwood			35	44	60	76	115
Continuous fir			38	48	66	83	125
Cast Iron	31	76	160	210	300	407	660

For the design of wood pipe two main points must be considered. The iron bands must be strong enough to resist the internal pressure and their compression against the wood must not be sufficient to indent the wood injuriously. In practice it is found that where round rods are used, an average bearing of half the diameter of the rod gives good results. With the softest woods it is generally assumed that it is not necessary to figure lower than about 500 pounds per square inch. The western manufacturers usually take 750 pounds per square inch, and for Douglas fir a considerably higher figure.

The Government Forest Service in a series of tests conducted at Madison, Wisconsin, found that a rod half inch in diameter would sink into a redwood stave under a pressure of 545 pounds per square inch. The measure of the crushing width was equal to half the diameter of the rod.

From this test it might be inferred that the practice of the redwood pipe manufacturers is unsafe. As this has been in vogue for some thirty odd years with success, there must be some good reason why failure does not take place, and that is probably due to the fact that the rod sinks into the wood until the bearing pressure per unit of area is reduced to an amount that will no longer crush the wood. For instance, if the bearing area were increased to the diameter of the rod instead of one-half the diameter, the pressure per square inch would be correspondingly reduced one-half. Even when the rod bears on one-half the diameter, there is some indentation of the wood, and the chances are that the full section of the stave is not permanently injured by this indentation.

In view of the test above noted, however, it would be conservative practice to use a figure of 500 pounds per square inch instead of 750, and this would apply to such soft woods as redwood, white pine and Norway pine. For such woods as Oregon fir, yellow pine, spruce, chestnut, etc., a value of 750 pounds would be conservative. For such woods as ash, oak, elm, beech, long leaf heart pine, birch, etc., a considerably higher figure should be used; but the only woods that have been considered as generally suitable for wood pipe have been redwood, fir, white pine and Norway pine, and sometimes cypress.

Assuming the pressure on the inside of the pipe is of uniform intensity, the pressure exerted against an iron band is exactly equal to the pressure on the internal surface of the pipe between the centers of two bands, so for the case of a round rod, if we take the bearing

area as equal to one-half its diameter, the formula for bearing pressure is easily deduced as follows:

$$L = \frac{Bd\ (D + 2T)}{2\,Dp} \tag{1}$$

in which L = spacing of rods between centers in inches.
D = internal diameter of pipe in inches.
p = pressure in pounds per square inch.
d = diameter of rod in inches.
T = thickness of the wood shell.
B = pessure in pounds per square inch on the wood.

If we consider flat bands, the formula becomes:

$$L = \frac{Bb\ (D + 2T)}{pD} \tag{2}$$

In which b = width of the band in inches, and all the other terms are the same as before. For the strength of the steel, the formulae are:

$$L = \frac{2\,a\,S}{pD} \tag{3}$$

or for the flat band:

$$L = \frac{2\,b\,t\,S}{pD} \tag{4}$$

in which a = the minmum sectional area of the steel band.
S = working strength of the steel in pounds per square inch.
p = the pressure in the pipe in pounds per square inch.
D = the diameter of the pipe in inches.
b = the width of the band in inches.
t = the thickness of the band in inches.

For wood pipe design S is usually taken between the limits of 12,500 and 22,000; 17,500 pounds per square inch being about an average figure.

It is seen from the above formulae that for small sizes of pipe where round rods are used, the spacing must be much closer than indicated by the formulae for steel strength, otherwise, the pressure on the wood would be excessive.

Where the strength of the steel is the criterion, the best practice for round rods is to upset the ends so that the base of the thread has the same area as the full section of the round rod, but it is very common, however, to use standard threads.

Probably the most usual diameter of rod is $\frac{1}{2}$ inch.

These remarks apply to what are known as independent rods and lugs, which are universally used with continuous pipe and are sometimes used with machine made pipe. The most common practice, however, with machine banded pipe is to use flat bands or wire, the winding being done in the factory with a machine that secures a uniform tension on the wire or band. The following table of round rods is useful in wooden pipe practice:

TABLE 4

DIAMETER OF ROUND ROD	AREA IN SQUARE INCHES	AREA AT BASE OF STANDARD THREAD	PERCENTAGE OF STRENGTH AT FULL SECTION
inch	*square inches*		
$\frac{1}{4}$	0.049	0.027	55
$\frac{1}{2}$	0.196	0.126	64
$\frac{9}{16}$	0.249	0.162	65
$\frac{5}{8}$	0.307	0.202	66
$\frac{3}{4}$	0.442	0.302	68

If we take the usual practice of wood pipe manufacturers and use a bearing pressure of 750 pounds per square inch on the wood, and use $\frac{1}{2}$-inch rods with standard threads and allowing a working stress of 17,500 pounds per square inch in steel, we find that for all sizes of pipe up to 20-inch inclusive, the spacing should be determined by formula 1, and for sizes above 20-inch the spacing should be based on the formula 3.

For pipe wound with round wire, if we assume that the spacing would be such as to produce a given pressure on the wood and a given tension in the iron, we may equate formulae 1 and 3, and obtain formula 5:

$$d = \frac{B\,(D+2T)}{\pi S} \tag{5}$$

in which d = diameter of the wire.

B = pressure per square inch against the wood.

S = stress in steel wire per square inch.

D = diameter of the pipe.

T = thickness of the pipe, all in inches: 2 inches for 24-inch and under, and 3 inches for 30-inch and above.

If we should assume S = 15,000 pounds per square inch, and

B = 750 and 500 pounds per square inch respectively,

the size wires would correspond to the following table:

TABLE 5

INSIDE DIAMETER OF PIPE	DIAMETER OF WIRE FOR 750 POUNDS PRESSURE ON THE WOOD	NEAREST CORRESPONDING B. W. G.	DIAMETER OF WIRE FOR 500 POUNDS PRESSURE ON THE WOOD	NEAREST CORRESPONDING B. W. G.
inches				
4	0.128	10	0.085	14
6	0.159	8	0.106	12
8	0.191	6	0.127	10
10	0.223	5	0.148	9
12	0.255	3	0.170	7
14	0.287	2	0.191	6
16	0.319		0.212	5
18	0.350		0.233	4
20	0.382		0.255	3
24	0.446		0.297	1
30	0.573		0.382	

The spacing of these wires would be the same whether formula 1 or 3 were used.

For independent rods and lugs we have to take the strength of the steel rod according to the sectional ara at the base of the thread. The following table gives the spacing of round rods, as calculated

TABLE 6

DIAMETER OF PIPE	DIAMETER OF ROD	PRESSURE IN POUNDS PER SQ. INCH					
		25	50	75	100	125	150
		Spacing between centers in inches					
inches							
4	No. 10 B. W. G.	4.02	2.01	1.34	1.01	0.80	0.67
6	No. 8 B. W. G.	4.13	2.06	1.37	1.03	0.82	0.69
8	No. 6 B. W. G.	4.57	2.28	1.52	1.14	0.91	0.76
10	No. 5 B. W. G.	4.62	2.31	1.54	1.15	0.92	0.77
12	No. 3 B. W. G.	5.18	2.59	1.73	1.29	1.04	0.86
14	No. 2 B. W. G.	5.48	2.74	1.82	1.37	1.09	0.91
16	½ inch rod, standard thread	9.45	4.72	3.15	2.36	1.89	1.57
18	½ inch rod, standard thread	8.40	4.20	2.80	2.10	1.68	1.40
20	½ inch rod, standard thread	7.56	3.78	2.52	1.89	1.51	1.26
24	½ inch rod, standard thread	6.30	3.15	2.10	1.57	1.26	1.05
30	½ inch rod, upset thread	7.83	3.92	2.61	1.96	1.57	1.31
36	⅝ inch rod, upset thread	10.23	5.12	3.41	2.56	2.05	1.71
40	⅝ inch rod, upset thread	9.20	4.60	3.07	2.30	1.84	1.53
48	⅝ inch rod, upset thread	7.67	3.84	2.56	1.92	1.54	1.28

from the above formulae, and based on the practice of the eastern manufacturers, the working strength of the steel being taken at 15,000 pounds per square inch and the pressure on the wood not to exceed 750 pounds per square inch. For sizes from 4-inch to 24-inch inclusive, the thickness of the shell of the pipe is assumed to be 2 inches and for sizes above 24-inch, 3 inches. For sizes from 4-inch to 14-inch inclusive it is assumed that the pipe is spirally wound with wire, and the spacing is computed by formula 1. From 16-to 24-inch, ½-inch rods with standard threads are used, and the spacing is computed by formula 3; for 30-inch pipe, ½-inch rods with upset ends; and for 36, 40- and 48-inch pipe, ⅝-inch rods with upset ends.

TABLE 7

NOMINAL DIAMETER OF PIPE	NUMBER B. W. G.	DIAMETER OF WIRE OR ROD	PRESSURE IN POUNDS PER SQUARE INCH					
			25	50	75	100	125	150
inches		*inches*						
4	13	0.095	1.90	0.95	0.63	0.47	0.38	0.31
6	12	0.109	1.82	0.90	0.60	0.45	0.36	0.30
8	10	0.134	2.01	1.00	0.67	0.50	0.40	0.33
10	9	0.148	2.07	1.03	0.69	0.51	0.41	0.34
12	7	0.180	2.40	1.20	0.80	0.60	0.48	0.40
14	6	0.203	2.61	1.30	0.87	0.65	0.52	0.43
16	5	0.220	2.75	1.37	0.91	0.68	0.55	0.45
18	4	0.238	2.91	1.45	0.97	0.72	0.58	0.48
20	3	0.259	3.11	1.55	1.03	0.77	0.62	0.51
24	1	0.300	3.50	1.75	1.16	0.87	0.70	0.58
30	Independent rods	0.500	6.00	3.00	2.00	1.50	1.20	1.00
36	Independent rods	0.500	5.84	2.92	1.94	1.46	1.16	0.97
40	Independent rods	0.625	7.18	3.59	2.39	1.79	1.43	1.19
48	Independent rods	0.625	7.02	3.52	2.34	1.76	1.40	1.17

Table 7 gives the spacing on the basis of 500 pounds per square inch pressure on the wood, the stresses in the steel not exceeding 15,000 pounds per square inch. For all sizes from 4- to 24-inch the thickness of the wood is assumed to be 2 inches, and from 30- to 48-inch inclusive, 3 inches. For sizes up to 24-inch, the round spirally wound wire is assumed to be used of the gauges shown, and from 30- to 48-inch inclusive independent rods and lugs with threads upset to give the full section of the rod. The spacing is calculated by formula 1, which applies for the entire table. For round rods this table represents the most conservative practice.

For flat bands machine spirally wound, on the basis of a working strength of 15,000 pounds per square inch for the steel and bands $1\frac{1}{2}$ inches wide, the following table of spacing in inches between center of bands will apply:

TABLE 8

	SIZES OF PIPE											
	4-inch	6-inch	8-inch	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	24-inch	30-inch	36-inch
25 pounds pressure												
B. W. G.	18	18	18	18	18	18	18	14	14	14	14	14
Spacing	11	11	11	8.81	7.35	6.30	5.51	8.30	7.47	6.22	4.98	4.15
50 pounds pressure												
B. W. G.	18	18	18	18	18	18	18	14	14	14	14	14
Spacing	11	7.35	5.52	4.41	3.68	3.15	2.75	4.15	3.74	3.11	2.49	2.07
75 pounds pressure												
B. W. G.	18	18	14	14	14	14	14	14	14	14	14	10
Spacing	7.34	4.90	6.22	4.98	4.15	3.55	3.11	2.76	2.49	2.07	1.66	2.23
100 pounds pressure												
B. W. G.	18	14	14	14	14	14	14	14	14	14	10	10
Spacing	5.51	6.22	4.66	3.74	3.10	2.66	2.33	2.07	1.86	1.55	2.01	1.67
125 pounds pressure												
B. W. G.	18	14	14	14	14	14	14	14	12	10	10	8
Spacing	4.41	4.97	3.73	2.99	2.48	2.13	1.87	1.66	1.96	2.01	1.60	1.65
150 pounds pressure												
B. W. G.	18	14	14	14	14	14	14	12	12	10	8	6
Spacing	3.67	4.15	3.11	2.49	2.07	1.78	1.55	1.81	1.63	1.68	1.65	1.69

It is seen that with flat bands for any practical spacing, the pressure on the wood is less than 500 pounds per square inch, and therefore the question of indentation of the wood is eliminated. For that reason for continuous wood stave and machine made pipe, where independent rods and lugs are specified, it has been proposed to substitue for the round rods flat iron of equivalent section, the ends being forged into the required shapes for connect-

ing with the lugs. The usual arrangement consists of a thread 5 inches long on one end and a buttonhead on the other. This with the single lugs are much more convenient to handle in the field than the double lugs and double threaded rods.

In the tables, the shell of the pipe has been taken as 2 inches thick for all sizes up to 24 inches inclusive and 3 inches thick for sizes above 24-inch in accordance with the practice of the eastern manufacturers, but the western companies use thinner staves for redwood and fir, the thickness ranging from about 1 inch for 4-inch pipe to $1\frac{3}{8}$ inch for 36-inch pipe.

While the above sizes of rods and bands and the spacing may not agree with the practice of the various manufacturers, it is given so as to afford the engineer a check on their proposals.

Machine spirally wire or band wound pipe has theoretical advantages over independent rods and lugs, which are put on and tightened in the field, because the tension produced in the factory is automatically uniform, and for the further reason that the pipe can be covered with a protective coating, which will add materially to the life of the banding. In case of leakage along the longitudinal seams, however, the independent rods and lugs can be tightened in the field. With the pipe made up in the factory the usual method of stopping the leaks is to drive wooden wedges between the band and the pipe, and this is usually done at the horizontal center, and affords a very quick and effective method for stopping this kind of leakage when it is not excessive.

There is some difference of opinion as to whether for machine banded pipe, wire wound is preferable to band wound pipe. Each of these types has its advantages. The wire winding presents the minimum surface to corrosion, while the flat bands present the maximum area of corrosion. On the other hand the flat band subjects the pipe to the least pressure on the wood and the round rod to the greatest. The flat band can be coated in a more effective manner than the round rod and where the life of the steel is likely to depend on the efficiency of the coating the flat band seems to offer the best proposition. In the majority of cases wood will outlast the steel winding, be it either round or flat.

WATER HAMMER

It must be understood that wood pipe is as much subject to water hammer as is any other, so in selecting the pressures due considera-

tion must be given to the possibility of material increase due to water hammer. There are many causes for water hammer. When the water in a long pipe is flowing at a high velocity, if a gate is shut down quickly, the velocity is reduced, and the inertia of the moving column of water causes increased pressure. If the line is flowing by gravity, and a heavy draft takes place in a low portion of the line, the discharge may be greater than the upper flatter portion of the pipe line is able to supply, in which case the column of water is likely to part, leaving a partial vacuum in a portion of the pipe line. This causes an acceleration of the moving column, so that if the draft is suddenly reduced the two columns will come together at an indefinitely high velocity, causing serious water hammer. The practical remedy for this situation is to use surge tanks or their equivalent.

The fundamental formula for water hammer is:

$$p = \frac{0.027\,LV}{T} \tag{6}$$

in which L = length of the pipe in feet.
V = velocity (ft. per second).
T = the time of extinguishing said velocity (seconds).
p = pounds pressure per square inch in excess of the hydrostatic pressure.

The pressure will reach a certain limit which depends on the length of pipe, the diameter, thickness and the quality of material.

To deduce a rational formula for water hammer for wood pipe to apply to a case when the velocity of water is stopped suddenly is a complicated process and at best uncertain. This branch of hydraulics, even for the simplest case, is more or less involved, and where we have the combined effect of the elasticity of the wood, of the steel bands and of the water, the complication is immeasurably increased. However, strict accuracy is not essential in any case, because the causes of water hammer are subject to wide variation. The simplest formula is:

$$p = V\left(\frac{3970\,E\,t}{Et + 294{,}000\,D}\right)^{\frac{1}{2}} \tag{7}$$

in which E = the coefficient of elasticity of the band.
t = thickness of the material of the shell, i.e., the band.
D = diameter of the pipe in inches.

V = velocity in feet per second suddenly stopped.

p = pressure in pounds per square inch due to water hammer for instantaneous extinguishment of velocity.

294,000 = coefficient of elasticity of water.

For steel bands having a coefficient of elasticity of 28,000,000 this formula reduces to

$$p = V \left(\frac{378,000\, t}{95\, t + D}\right)^{\frac{1}{2}} \tag{8}$$

As an example assume the pipe to be 24 inches, 10,000 feet long, thickness of band $\frac{1}{8}$ inch, velocity 5 feet per second. If the velocity is suddenly stopped, p would equal 181 pounds per square inch. By applying the fundamental formula it is seen that if the velocity is stopped in 7.4 seconds, or less, the result would be the same as if it were stopped instantly.

Incidentally it will be noted that the effect of sudden stopping is independent of the length of the pipe, and as the water hammer can never be greater than that due to sudden closing, we have a certain amount of insurance against the effect of closing valves too quickly. This insurance, however, is more imaginary than real, because in both formulae the pressure due to water hammer is proportional to the velocity reduced, and there are many conditions which will produce accelerating and unduly high velocities, as for instance, a high rate of draft at a low portion of a pipe line, the sudden release of an accumulation of air, or anything that will produce a temporary vacuum in a portion of the line. Any one of these conditions will cause an acceleration, and water will run down the incline according to the law of falling bodies, and develop an indefinitely high velocity, which is suddenly extinguished when it meets the still column of water ahead.

The practical aspect of this matter is that everything possible should be done to prevent water hammer. The most effective remedies are in gravity lines to divide the total length into short sections by leveling reservoirs or surge tanks, and to provide a good design of automatic air valve on all the summits. For pumping where the line is long, water should be pumped into an elevated reservoir or standpipe close to the pumping station, and if this is impracticable, large air chambers should be used, and means for charging them with air. Where the pumps are centrifugal and run by electricity, the power occasionally goes off suddenly. The column

of water, however, continues on some distance, causing a reduction of pressure at the pumps often below the atmosphere. The water column will then recede by gravity until it reaches the check valve at a high velocity, and as for this situation air chambers are not usually provided, a serious water hammer takes place, which is the cause of a great many broken discharge mains. A simple remedy is to connect the discharge main outside of the check with a tank kept full of water and between the tank and the discharge main should be a check valve opening outwardly. The main will then be kept full of water, and as soon as the velocity is reduced to zero the column of water will not recede and no water hammer will take place.

DISCHARGING CAPACITY OF WOOD PIPE

Much has been written concerning the formula for flow in wood pipe. The writer is of the opinion that the formulae such as Hazen and Williams, Chezy and others, for new cast iron pipe are applicable to wood pipe of any age. It is quite probable that the flow through a perfectly new straight cast iron pipe would be slightly greater than for wood pipe of some age, due to the fact that the interior surface of the wood is more liable to have attached to it a film, or scum, which slightly reduces the flow.

The difference, however, is not very material, but for many situations the reduction in flow in cast iron, even in a very few years, makes the discharging capacity of the wood pipe much superior. For soft mountain waters and those of the coast, where the color is high, cast iron pipe is likely to reduce within ten years, more than 20 per cent of its original capacity, due to tuberculation. Wood pipe is entirely free of this difficulty.

The writer made very careful and repeated tests of the flow through ten miles of 24-inch wood pipe where the velocity was about 4 feet per second, and found the coefficient in Chezy's formula to be 111. In this case the pipe was not perfectly round. If it had been round the flow would have increased. This phase of wood pipe operation is very important. Where the pipe is in a trench with a considerable fill over it and the pressure low, the pipe will assume an oblate form, the vertical diameter being materially less than the horizontal. The effect is to reduce the hydraulic mean radius and consequently the flow. When the pressure is increased materially, the pipe will become more nearly circular in form, and the coefficient will cor-

respondingly increase. This is one reason why a great deal of trouble is experienced with leakage in wooden pipes. If it is subject to low pressure when installed and then after some years the pressure is increased materially, leakage is apt to develop along the staves as well as in the joints. The remedy is to operate constantly this class of pipe under fairly uniform pressures.

SHORT WOOD PIPES

There are many wood pipes in service for flumes of short lengths, and an engineer is often at a loss to know how to calculate the flow in a very short pipe. The main point is to take account of the various losses of head that occur. The following formulae will apply to any pipe, be it short or long:

$$Q = \frac{0.3927\, D^{\frac{5}{2}}\, H^{\frac{1}{2}}}{\sqrt{\frac{L}{c^2} + 0.00582\, D}} \tag{9}$$

in which Q = cubic feet per second.
D = diameter in feet.
H = total head in feet.
L = length in feet.
c = Chezy's coefficient.

Where the flow is in gallons per 24 hours, and the diameter of the pipe is in inches, the formula becomes:

$$q = \frac{508.9\, d^{\frac{5}{2}}\, H^{\frac{1}{2}}}{\sqrt{\frac{L}{c^2} + 0.000485\, d}} \tag{10}$$

in which q = gallons per 24 hours.
d = diameter of the pipe in inches.

These formulae allow for velocity head and entrance head equal to half the velocity head.

It will be noted that No. 9 is a modification of Chezy's formula, and if this be reduced to velocity and the head taken as feet per thousand, and the pipe is indefinitely long, the formula reduces to:

$$V = \frac{C\sqrt{Dh}}{63.2} \tag{10$\frac{1}{2}$}$$

in which D = diameter in feet
h = head in feet per thousand

Nearly all the investigators of the flow through pipe have concluded that the Chezy formula cannot be used with accuracy unless the value of C is changed to correspond to different diameters of pipe.

Scobey, Hazen and Williams, Moritz and others have made a very careful study of the flow of water in pipes, and Scobey's results and Hazen and Williams' correspond very closely. Taking Scobey's results on the basis of a loss due to friction of one foot per thousand, we have

for a 12 foot pipe—$C = 148$
for an 8 foot pipe—$C = 127$
for a 6 foot pipe—$C = 134$
for a 1 foot pipe—$C = 118$

and the formula of Hazen and Williams would give practically the same results although slightly smaller, but it is more convenient to use the Chezy formula even if we give to C different values corresponding to the diameters of the pipes, because the formula can be reduced to such a form as will allow for velocity and entrance heads, which is not practicable with the other formulae.

It is generally supposed that all the losses of head except that of friction vary with the square of the velocity. The importance of having a formula that is applicable for any length of pipe is shown by the fact that where only friction is taken into account, we would have a velocity in a 12-foot pipe of 6.05 feet per second while if the pipe were 1,000 feet long the true velocity would be only 4.4 feet per second.

ECONOMICAL COMPARISON OF WOOD AND CAST IRON PIPE

For all ordinary sizes of pipe it is generally recognized that the present standard is cast iron pipe. For water purposes there is more cast iron pipe used than all other pipes combined, the reason being that cast iron pipe can be made absolutely tight under all circumstances and will remain so under all variations of pressure. For very large sizes, however, it is too costly as compared with wood or steel, and under many situations the reduction in capacity due to tuberculation is so serious that engineers will prefer a reinforced concrete pipe or wood pipe.

Undoubtedly in regard to extensive use, wood pipe comes next to cast iron. It may be conservatively stated that cast iron pipe

will last 100 years, when under average cases, it may be stated that a wood pipe would not last more than 25 years. There are many modern wood pipes that have been giving good service much longer than 25 years, but when we compare with cast iron it is best to assume the short life for the wood pipe. Therefore, we may say that the life of a cast iron pipe is 100 years and that of a wood pipe 25 years.

As an example, let us take 24-inch continuous redwood pipe and assume a life of 25 years. Say the wood pipe will have to be renewed

TABLE 9

	WOOD	CAST IRON
Initial cost of 24 inch diameter pipe	\$41,900	\$67,600
Increase in cost of cast iron pipe to obtain 20 per cent increased capacity		6,450
Initial cost for equal average capacity	\$41,900	\$74,050
Annual charges		
Wood Pipe, Repairs 1 per cent, taxes 0.6 per cent	\$670	
Cast Iron Pipe, Repairs 0.25 per cent, taxes 0.6 per cent		\$630
Present Worth of \$41,900 at 5 per cent for renewal in 25 years	\$12,373	
Present Worth of \$41,900 at 5 per cent for renewal again in 50 years	3,654	
Present Worth of \$41,900 at 5 per cent for renewal again in 75 years	1,079	
Present Worth of \$41,900 at 5 per cent for renewal again in 100 years	319	
Present Worth of \$670 per year for 100 years at 5 per cent	13,400	
Present Worth of \$630 per year for 100 years at 5 per cent		12,600
Initial cost for equal average capacity	41,900	74,050
Total present worths	\$72,725	\$86,650

four times in a hundred years and cast iron pipe only once at the end of 100 years. Let us take the average discharging capacity for the wood pipe as 20 per cent greater than that of cast iron. The initial cost of 10,000 feet of wood pipe for 65 pounds working pressure is \$41,900. The same amount of cast iron pipe would cost \$67,600. To obtain an increase of capacity of the cast iron pipe to make it equivalent to that of wood pipe a larger size would have to be put in If a 30-inch pipe is used, the increase of capacity would be 75 per cent,

and the increased cost would be $24,200, so therefore to get an increased capacity of 20 per cent, in the same ratio, the increased cost of the cast iron pipe would be $\frac{20}{75}$ of $24,200, or $6,450, or a total initial cost of $74,050. We may take the cost of repairs of the wood pipe as 1 per cent per annum and the taxes as 0.6 of 1 per cent, and for the cast iron pipe we may take the annual repairs as $\frac{1}{4}$ of 1 per cent and the taxes as 0.6 of 1 per cent as before, so that the annual charge for wood pipe would be $670 and for cast iron pipe $630. This is all shown in table 9.

The saving of putting in wood pipe based on present worths would therefore be $13,925, which is nearly 19 per cent of the initial cost of the cast iron pipe.

If we should take machine banded eastern pine wood, the initial cost would be $28,900 as against $41,900, and the present worth figures obtained for wood pipe by the same method would be $50'-125 and for the cast iron pipe $86,650, or a saving of $36,525 in favor of the wood pipe, which is 50 per cent of the initial cost of the cast iron pipe. For larger sizes of pipe the difference becomes greater.

For 12-inch machine banded eastern pine pipe the initial cost would be $14,900 for the wood pipe and $26,900 for the cast iron pipe, but to obtain 20 per cent increased capacity for the cast iron pipe by the same method as before would cost $2,170, or a total initial cost of the cast iron pipe of $29,070. The annual cost of repairs and taxes for the wood pipe would be $238, and for the cast iron pipe $247, so that the present worth of the total cost of the wood pipe would be $25,847, and of the cast iron pipe $34,027, or a saving of $8,180, which is about 28 per cent of the initial cost of the cast iron pipe.

When a financial comparison on a rational basis shows such a material advantage of wood over cast iron pipe, the question naturally arises, why is cast iron so universally preferred by most of the leading engineers? It is, no doubt, because there have been so many unfortunate experiences with wood pipe. Successful installations cause only casual comment and consideration, but when a failure takes place it has the same effect on engineering sentiment as does a moral scandal on that of the public; successes are forgotten and the failures vividly remembered.

Then again, cast iron pipe is suitable for nearly all situations and conditions of operation under the widest range of pressure and flow, and even in the circumstances of distribution mains where the carrying capacity is reduced as much as 75 per cent, its reputation for

reliability and ruggedness is not destroyed; the owners comforting themselves, where they happen to know about it, with the feeling that they can always restore the capacity by cleaning. On the other hand, there are frequently conditions that would give no trouble with cast iron pipe where wood pipe would be entirely unsatisfactory. It must be admitted that most of the wood pipe companies are coming more to realize these facts, and of late years refuse to furnish pipe where the conditions are unfavorable. Wood pipe is sometimes shipped before needed and left out exposed to harmful weather conditions, causing warping and permitting dirt to get into the stave joints. In some important installations, sap and knotty wood has been used which adds further to its discredit.

In this connection I would call the attention of engineers to some very valuable data on the "Condition of Wood-Stave Pipe on Reclamation Projects," published in the *Engineering News-Record*, March 23, 1922. This article gives the results of 195 installations of wood pipe that have been in service for from five to twenty-five years.

The following are some important points in regard to specifications and conditions:

Pressure. The maximum working pressure to be 200 pounds per square inch, preferably 150 pounds.

Strength of iron and wood. At maximum working pressure the steel bands shall not be subjected to a greater stress than 15,000 pounds per square inch at the weakest section, and the wood shall not be subjected to a greater external pressure than 750 pounds per square inch; preferably 500 pounds, when the round rod has a bearing surface on the wood not to exceed the radius of the rod.

Quality of the wood. Wood may be redwood, fir, white pine, Norway pine or cypress, thoroughly seasoned and before working into staves, air-dried; free from loose or black knots or any knots that pass more than half way through the wood, sap wood, wind shakes, check cracks, dry rot, pitch pockets or pitch seams. For machine spirally banded pipe the gauge of the steel should not be less in thickness than no. 14 BWG except for low pressure: for pipe whose diameters are 8 inches and below no. 18 gauge will be permitted.

The form of the staves and the method of banding shall conform to the manufacturers' standards subject to the approval of the purchaser's engineer or inspector.

All material including the coating shall be inspected before and after fabrication and on the ground when ready to lay, and acceptance is subject to engineers' or inspector's approval.

Storage. After pipe or staves are made, ready for laying, they should be stored in a dry place until ready to be laid.

Leakage. After the pipe is laid, always under the supervision of the manufacturers a test for leakage shall be made under approximately the working pressure for which the pipe is specified. The leakage shall not exceed 700 gallons per 24 hours for each inch of diameter of pipe per mile.

Carrying capacity. While the carrying capacity of wood pipe may be in many cases more favorable, it is recommended that the value of C in Chezy's formula be taken as 110, in which case the formula for flow would be:

$$q = \frac{56{,}000\, d^{\frac{5}{2}}\, H^{\frac{1}{2}}}{\sqrt{L + 5.87\, d}} \tag{11}$$

in which d = internal diameter of the pipe in inches.
H = total head available in feet.
L = total length of pipe in feet.
q = flow in gallons per 24 hours.

This formula is suitable for pipe of any length down to about 10 diameters and takes into account the velocity and entrance heads.

The ideal conditions for wood pipe installation are where the pipe is constantly subjected to the pressure from an elevated reservoir and where the pipe is never allowed to become empty except temporarily for repairs or emergency. For pipe covered up in a trench it may not be serious to have it empty occasionally for a week at a time, but were the pipe is exposed in the open air, the sun would likely dry and warp it, so exposed pipe should be kept constantly full of water under material pressure.

Wood pipe should never be laid in cinder fill ground or any place where mine water can reach the bands. Under these conditions with any kind of band or coating other than cement, the bands will rust and break within a very short time.

The same observations would be equally applicable to steel or cast iron pipe.

In conclusion, from our knowledge of the present state of the art of water pipe, it may be stated that the best pipe that could be obtained for any purpose would be cast iron with some sort of a

non-corrosive and indestructible inner lining, but, in ten years from now, this statement may be obsolete, and the writer is of the opinion that we are on the eve of great and fundamental improvements in water pipe manufacture.

It is believed, however, that it will be many a decade before the use of wood pipe ceases to be warranted. Wood pipe is in use by at least 500 municipalities and water companies scattered throughout the United States.

In the preparation of this paper I wish to acknowledge my indebtedness to various companies manufacturing wood pipe from whom I have obtained valuable data and discussions. Among the many valuable discussions on this subject I wish to call attention particularly to the splendid paper by Fred C. Scobey on the Flow of Water in Wood Stave Pipe, U. S. Dept. of Agriculture, Bulletin 376.

SOME PHASES OF THE STREAM POLLUTION PROBLEM[1]

By J. K. Hoskins[2]

The increasing pollution of our streams and coastal waters has been for a considerable time a matter of serious concern to sanitarians and to those interested in the promotion of our public health, and will become a more difficult problem as our population increases, and these waters are used more intensively in the industries and as sources of public water supply. The problem is an intricate one and touches in some phase either directly or indirectly the welfare of the entire population.

There are several viewpoints from which stream pollution may be considered, more or less overlapping, yet distinct, namely, the economic, the aesthetic or recreational, and the effect on public health.

The economic side of the stream pollution problem is one that has been given little consideration until recently, but is gradually coming to be accorded the importance it deserves. Much has been said and written, demanding a return to the pristine purity of our water courses and the elimination of all pollution, regardless of the cost of such elimination. The practical absurdity of this position is becoming more and more apparent, however excellent it may seem in theory. The requirements of modern civilization demand an intensive use of our natural resources. The reasonable use of natural watercourses cannot be excluded, since they constitute one of our greatest national assets. There are, then, real, practical, economic limits beyond which it is unwise to go, in forcing abatement of stream pollution. The determination of this limit for each stream presents a problem in itself. For example, an economic study of a definite situation may disclose that it would be cheaper to procure a new source of water supply for one small municipality rather than to treat the sewage of a large up-stream city. Or it may be found more economical for an industry to change its location entirely or

[1]Read before the meeting of the Illinois Section, March 29, 1922.

[2]Sanitary Engineer, U. S. Public Health Service.

even to go out of business, rather than to incur the unreasonable expense of treating a refractory industrial waste. In general, the value of the benefits to be derived from stream purification must be weighed against the costs of elimination of pollution.

Most streams are used to a considerable extent for recreational purposes, such as for bathing, fishing, and boating, uses which are greatly retarded or even eliminated if excessive pollution is allowed to occur. The value of this use is generally intangible, and difficult to state in dollars and cents, but is, nevertheless, real. Perhaps the most common illustration of the excessive pollution of any stream is that all the fish in it have been killed. To be unable to catch fish in the brook that was formerly the ideal fishing place of our boyhood, is the superlative in condemnation of pollution in that particular stream. It must be stated, too, that the nature and variation of fish life present is a sensitive indicator of the extent of pollution in any watercourse. Boating and bathing are also affected by excessive pollution and in many cases such usage of a polluted stream becomes an important public health problem. One's esthetic sense is also revolted at the sight of grossly polluted watercourses. Floating debris, garbage, and sewage deposited along the banks, ebullition of gas from decaying sludge in stream beds, and highly discolored waters from domestic and industrial wastes afford ample grounds for complaint and demand for betterment of such conditions. While all of these factors are of secondary significance from the standpoint of health or economics, they constitute a most important phase of the stream pollution problem and the one that is, and will be, responsible for the largest share of public support in any movement for elimination of objectionable pollution.

The effect of stream pollution on public health is undoubtedly the most important phase of the problem. We must depend primarily on our streams for sources of water supply, and, in the interest of health, we must above all demand that these supplies be adequate and free from contamination. If streams are to be used for water supplies, they must either be unpolluted or methods of artificial purification of the water must be adopted to insure a suitable quality. In our present knowledge of water purification it is economically impossible to produce pure water in quantity from a grossly contaminated source. The effluent from any purification plant bears a definite relation to the condition of the raw water. It is important, therefore, that sources of water supply be not pol-

luted beyond a certain point, if the health of the community using the supply is not to be imperiled.

On the other hand, public health demands the prompt and efficient removal of body wastes, and this has been found to be best accomplished by the water carriage method of disposal. The proper method of treatment and disposal of these liquid wastes, or sewage, is therefore a public health problem closely allied to those of stream pollution and public water supply.

Because of the increasing seriousness of stream pollution, as affecting interstate watercourses, and of the demand for remedial legislation for such conditions, Congress, in 1912, authorized the Public Health Service to "investigate the diseases of man and conditions influencing the propagation and spread thereof, including sanitation and sewage, and the pollution either directly or indirectly of the navigable streams and lakes of the United States." In compliance with this authority, the Service organized and has since conducted researches to determine the fundamental factors operative in the processes of stream pollution and stream purification. The scope of the study was made sufficiently broad to cover the various types of problems to be met with, and was divided into three separate parts.

A study of the coastal waters and tidal streams was undertaken under the direction of Surgeon (now Surgeon General) Cumming. Much information was obtained on the effect of pollution on the shell fish industry and methods were developed for counteracting this pollution as it affected the production of shell fish.

Studies of the nature and treatment of industrial wastes were conducted under the supervision of Professor Earl B. Phelps. Experimental treatment plants were operated for sufficiently long periods of time to demonstrate the most effective method of handling various types of industrial wastes. At the same time much detailed data was collected pertaining to the nature and constituents of these trade wastes. The results of these studies have been published as Bulletins of the Public Health Service. Both of these lines of study have been discontinued, temporarily at least, because of insufficient funds to carry them further.

Studies of stream pollution and stream purification, in the inland rivers, have been organized and continued under the direction of Surgeon W. H. Frost. Intensive studies of the various phenomena

in stream purification have been carried on, with Cincinnati as a headquarters.

The greater part of the field work has been conducted on the Ohio River and its watershed. More recently the Illinois River has been under observation to determine the general applicability of the fundamental laws observed as a result of the Ohio River work.

These studies have been promoted with certain definite objects in view, although their complete attainment will require a great deal of time and the expenditure of considerable labor. These objects are briefly discussed below.

The first object is to determine the nature of the various important primary types of polluting substances in fundamental terms, and then to ascertain and evaluate the effects of these when discharged into a stream. An intelligent study of stream pollution cannot be undertaken, unless we take into account the origin and constitution of various polluting substances. This means that the actual agencies of pollution must be carefully considered and these various forms of pollution be reduced to some common standards of measurement. We must know of what domestic sewage consists, what the constituents or properties of such sewage are, and, if possible, reduce these properties to some definitely determined unit, such as the amount of oxygen required to oxidize the organic matter contained in the per capita contribution. In the same way, we should know the characteristics of the various industrial wastes, so that all of these may be reduced to fundamental and common units. For packing-house wastes, for example, we should know some unit, such as the average amount of nitrogen contributed to the waste per animal slaughtered, or the average amount of oxygen used up in oxidizing the wastes resulting from each animal handled. If some such relationships may be established, then we can say, for instance, that a contributing population of one thousand will require a definite number of pounds of dissolved oxygen in the stream to oxidize the sewage, or that 1000 animals will contribute a definite number of pounds of nitrogen to the wastes from the packing plant in which they are slaughtered, or will require a certain amount of oxygen for oxidation of these wastes. Similar fundamental units are necessary for each of the important industrial wastes that go to make up the combined pollution contributed by the community. Where there are particular wastes of importance, as, for example, the wastes from corn products industries, these should be studied in a similar way,

so that their effect on the stream may be stated in readily ascertainable units of production, such as per bushel of corn used.

Another object is to discover, if possible, the fundamental laws, if such exist, that operate in stream purification. The observed purification is a progressive process that gives evidence of following definite laws, although these may be complex and not easy of determination. There are many factors that modify the rate of purification and these may be so interwoven as to prevent separate analysis. It is certain, at least, that the old statement, that a flowing stream purifies itself in seven miles, is far from correct. We know that velocity, or time of flow, is a controlling factor, rather than distance. Temperature, both of the water and of the superimposed air, turbulence of the water, and the physical content of the water itself, exposure to light and air, all of these, and others, are factors that affect the rate of purification. Each must be studied under controlled conditions, if sound theories of purification are to be evolved.

The third object is to determine what agencies are active in the process of stream purification and the significance of the rôle of each agency in this process. It is necessary to know, for example, what particular organism or constituent is responsible for a specific, observed change in the chemical composition of the various compounds constituting pollution; what rôle such organism or constituent plays in effecting the specific change, and what the significance is of each of these factors. This is in itself a complex problem, of which little is known. We know, for instance, that in the purification process, the death rates of bacteria are a measure of the rate of purification, but we do not know what that death rate is, to what it is due, or what all of the factors are that retard or accelerate it. We believe that the plankton, both animal and vegetable forms, play an important rôle in purification processes, but we know very little about their specific activities and their food habits, or the net effect of the products they generate, such as oxygen. We know that certain classes of organisms break down into simpler forms the organic matter present as polluting substances, but just what these processes are we cannot say. We know that the process of purification depends upon the oxidation of organic matter present, but we know little of the rates at which this oxidation proceeds, or the factors that favor or retard this rate. In the process of purification certain chemical changes take place, but with our present

knowledge we have great difficulty in interpreting the meaning of these changes, modified as they are by so many other active agencies. These are some of the many problems to be solved, if we are to have an understanding of what may appear, at first thought, to be the simple problem of stream purification.

The Service plans also to make a practical study of polluted streams that are of sufficient size and representative of average conditions, to determine the net effect of various types of pollution, where these types are mixed in a practical way, and to verify the theoretical conclusions arrived at concerning stream purification. After the required data are obtained, regarding the nature and extent of the various polluting wastes, their actual effect on the watercourse into which they are discharged must be observed, and the rate at which the stream is able to recover from the pollution load must be determined. These observations should cover sufficiently long periods of time and be of broad enough scope in order that the conclusions drawn may be of general application to other places, where similar sets of conditions occur. This is the phase of the problem that is now being studied by means of the laboratories located along the Illinois River, and which will be discussed in detail later.

The results of these studies should be of practical value and general application, so that costly and tedious technical investigations need not be conducted in each individual case to determine the stream conditions to be expected from known amounts of pollution. This is perhaps the most difficult problem of all. If the solution is capable of clear statement, it should be of great value in determining for any stream what degree of purification may be anticipated at any point, due to a known amount of pollution being contributed at some point upstream. That is, if to any stream of known volume and velocity of flow, we know a population of, say 100,000, is contributing domestic sewage, it should be possible to determine within reasonable limits the amount of pollution that might be expected to be present at a point 100 miles downstream at a waterworks intake. Or, again, we should be able to estimate the effect on a surface water supply of an increase of 50,000 inhabitants on the upstream watershed, or the additional load that such an increase might be expected to contribute to a water purification plant. These conclusions should be possible without the use of extensive and costly laboratory examinations covering ex-

tended periods of time. Furthermore, such complete surveys should be of aid in establishing reasonable limits of permissible pollution and to indicate the point at which treatment of wastes must begin if objectionable conditions in the receiving stream are to be avoided.

These are some of the phases of the stream pollution problem that the Public Health Service has begun to study. Much preliminary work has been necessary to devise and to perfect methods and to collect existing data and to reduce previous independent studies to comparable terms that might be of value. To obtain the greatest benefit from the organization dealing with the study of interstate streams, the work was separated into three main divisions all of which have been carried on simultaneously with the objects in view as outlined above.

The first division has been conducting studies and experiments on the nature and effect of polluting agencies. Analyses of various classes of industrial wastes and sewage have been carried on, to establish if possible the relationship between the constituents of the waste and fundamental factors active in the production of the particular waste, regardless of the volume of the waste itself. Thus, in scouring a pound of wool, a relatively uniform amount of nitrogen is contributed to the washing waters, regardless of whether the amount of water itself is great or small. Similarly, for domestic sewage, certain constituents are more nearly proportional to the per capita population contributing than to the volume of sewage discharged. The most economical methods of treatment of such wastes have been studied at the same time.

The second division has been concerned with the phenomena of stream purification. Detailed data are being assembled dealing with the nature and extent of various kinds of pollution being contributed to certain large streams. Studies are being made of the hydraulics of these watercourses, as their velocities of flow, and amounts of water contributed by tributaries and other sources of inflow. In addition, laboratories for studying the actual degree of purification being effected at various points throughout their courses, are being operated for sufficiently long periods of time to supply reliable data.

The third division of the work has to deal with the effect of intensity of pollution on the public health, principally through the agency of the public water supply. This has involved a rather detailed study of the present methods of water treatment in various

types of plants, and the efficiencies of such plants under varying pollution loads. Studies have also been made of the actual conditions of public health in different communities, where various types of treatment plants and varying grades of water are being supplied for consumption. This work has included the making of detailed sanitary surveys of every municipality having 10,000 population, or over, on the Ohio River watershed, as well as of the greater number of cities in the eastern and North Atlantic states.

As a part of this general program, a study of conditions existing throughout the Illinois River is at present in progress. The work is not being done primarily from the viewpoint of a local problem, although some phases of it are of considerable local interest. From what has been said, it is evident that a study to fulfill the objects of the Public Health Service, as outlined above, must be made on a stream where all possible factors can be obtained in well-defined units, if results of general application are to be secured. Hence, it is advisable to choose for such study a stream where definite values are obtainable to the greatest extent. The Illinois River meets these requirements to a considerable degree.

The pollution contributed to the Illinois is largely added at one point and from a well-defined area. There is little dilution of this pollution by tributaries of the main stream, so that the observed degrees of pollution noted at various points along the channel need not be corrected appreciably because of these modifications.

The sources of pollution are known, or are readily ascertained. The population discharging sewage into the main drainage canal is clearly defined. Likewise the nature and extent of the various industries in this area have been enumerated and data are available relating to the nature and amounts of industrial wastes discharged to the drainage canal.

The volume of flow of the Illinois River is also possible of determination and the amount of water diverted from Lake Michigan is a matter of record. Surveys of the entire river channel have been made by the United States Corps of Engineers, who also maintain gages throughout the stream whereby the daily flow at any point may be computed.

Many additional pertinent data have been collected by other state and local agencies which, being available, have made the Illinois a most attractive stream for a study of the kind at present being undertaken.

In the present study of the Illinois River, the work has been separated into three main divisions. All of these are being carried along simultaneously and consist of hydrometric studies, sanitary surveys, and laboratory analyses of samples of river water.

The hydrometric studies consist in making field determinations of the daily flow of the main stream, at various points, and of all tributaries as they discharge into the main stream. This is done by making frequent current meter measurements of flow at various known gage heights. Numerous gages carefully located are read daily. From these records the daily volume of flow is computed, using the current meter measurements as a basis. A considerable amount of this work is being done in coöperation with the United States Geological Survey, which is furnishing most of the gage readers. These data are being assembled in such a way that it will be possible to state in reasonably accurate terms the total amount of water passing any sampling section on any day and the volume of water added to the main stream by each of the important tributaries of the Illinois. The amount of water being diverted daily from Lake Michigan is also known, so that the total volume of stream flow is determinable.

Another phase of the hydrometric studies has to do with the determination of the velocity of flow throughout all parts of the river. Because of the complete channel survey made by the United States Corps of Engineers, the most feasible method of determining the velocity was found to be by means of the displacement method, correlated with slope of channel as indicated by gages placed throughout the stream length. These computations are so arranged that it is possible to determine the time consumed for the water to pass from one sampling section to the next below and in that way to establish the effect that has taken place in this time interval.

Sanitary surveys have been practically completed of all important industries and municipalities contributing wastes to the stream in order to determine the extent of the contribution of pollution. Much of this information had been collected previously by various organizations, but personal visits have been made to industries and towns along the river where data were not otherwise available. It is hoped by this information to establish in fundamental terms the relationship between known populations and pollution effects observed in the stream.

The laboratory studies, concerned with the actual determination of the daily condition of the river water at numerous points throughout the course of the stream, have been the most tedious and expensive part of the work. In order to obtain reliable results the laboratory work must be carried on over a sufficiently long period of time to observe seasonal and other changes that may take place. Needless to say, the work must be thoroughly standardized and accurately performed, in order that results from all laboratories are strictly comparable in every respect.

Four laboratories have been established on the Illinois River, the main laboratory and headquarters at Peoria, and branch laboratories at Joliet, Beardstown, and Kampsville. The locations were so chosen that samples from practically every section of the river could be delivered to one of these laboratories promptly for complete examination. Definite sections were established, from which daily samples could be collected and either brought or shipped by express to the most accessible laboratory. A special type of sample collecting apparatus was devised by means of which bacteriological and chemical samples can be taken in separate bottles at the same time, and from the same water stratum. It is hoped to continue this intensive laboratory work over a complete year.

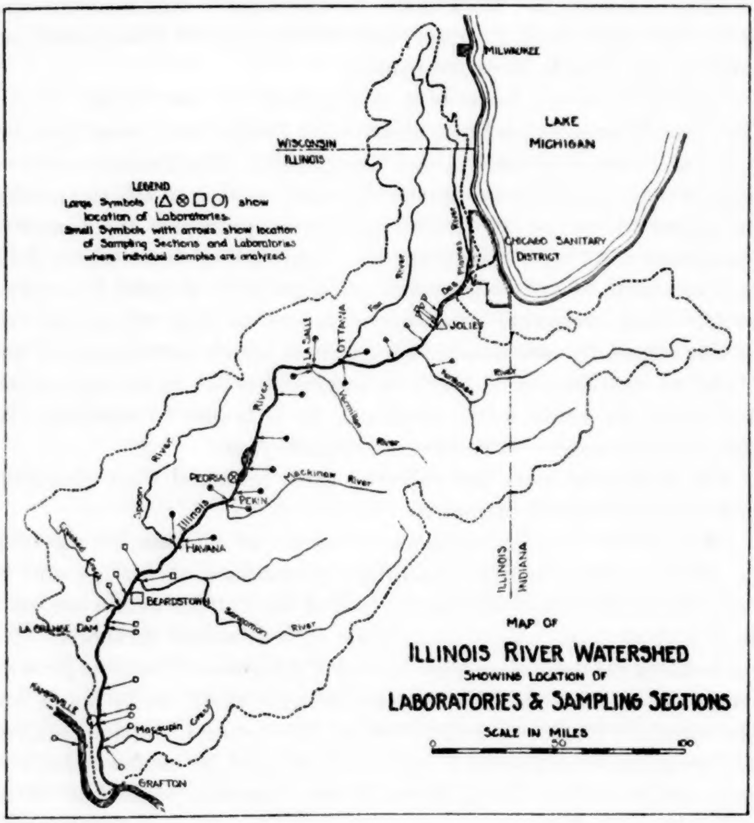
The analytical work has followed three principal lines—bacteriological, chemical and biological.

Daily bacteriological analyses are made on all samples received, in strict accordance with carefully standardized technique and by carefully trained bacteriologists. All of the culture media are made at a central point and in accordance with standard methods. The bacteriological determinations consist of numbers of bacteria growing on gelatin at 20°C. in 48 hours, and on agar at 37° in 24 hours, and the numbers of B. coli computed by the decimal dilution method. Differentiation of types of B. coli, grain or fecal, by means of dextrose peptone phosphate broth, is made on a certain percentage of all coli cultures isolated.

The chemical work has been considerably reduced because, from past experience, it has been found that many complete mineral analyses are not justified. The alkalinity and turbidity are determined for all samples collected, as well as the immediate dissolved oxygen. The biochemical oxygen demand is also determined for every sample, using the dilution method and incubating the sample for a period of 5 days at a temperature of 20°C., and ascertaining

the dissolved oxygen present at the end of this incubation period. We believe this to be one of the most valuable tests at present in use for indicating the degree of pollution and the rate of purification that may be expected to occur from such pollution.

Composite samples, covering periods of ten days, are made, preserved with sulphuric acid, and analyzed for certain constituents



such as oxygen consumed, free ammonia, Kjeldahl nitrogen, and nitrogen oxides, including nitrates and nitrites. It has been found by a careful series of experiments that the sulphuric acid preserves such samples without change for a sufficiently long period of time to make this method entirely practicable.

The biological part of the laboratory studies has been designed more or less to supplement the extensive work of the State Natural

History Survey, and to correlate the present findings with the observations so carefully made by Professor Forbes and his workers. Consequently, only a small part of the biological field is being touched. Monthly samples of bottom sediment are collected at selected points and the nature and amount of the contents of these various sludge deposits are noted. Weekly samples of plankton are collected from many more sampling stations, and these plankton forms are counted, identified, and recorded. Special attention is paid to the presence of those forms which, in their processes of development, generate and impart oxygen to the surrounding water, and thus influence the rate of oxidation of the organic matter present.

The accompanying map of the Illinois watershed shows the location of the laboratories, indicated by large symbols, while the arrows with the small symbols indicate the points at which daily samples of water are collected for analysis. Sampling sections indicated by a certain symbol, as a triangle, indicate that samples from this point are analysed in the laboratory designated by a similar symbol.

The data being collected have not yet been arranged in final form, so that it is not practicable at this time to draw definite conclusions as to the rates of purification to be expected, although the results seem to follow the same general trend of those obtained in the Ohio River work.

FIRE PRESSURE

By Charles R. Henderson[1]

There seems to be no good reason why the dangerous and wasteful practice of increasing pressure on hundreds of miles of water mains, every time there is an alarm of fire, should be continued. It was at one time the best method, especially in small towns where a pressure adequate for fire streams was not necessary for domestic supply and the domestic pressure was not adequate for fire streams. Mains then were small, hydrants were far apart, fire departments were manned by volunteers, steam fire engines were expensive to install and expensive to keep in readiness for service, requiring additional horses and one or more skilled mechanics to operate the engines.

Conditions have changed. The automobile has revolutionized fire departments as well as many other things. Now the same vehicle that carries the hose, the men and the tools, to the fire, is also the fire engine when a small and inexpensive pump is added to the apparatus. The driver of the automobile apparatus is also the "engineer" and "fireman" of the pumper.

Some cities are already giving up the practice of raising pressure in the mains as the fire departments acquire pumpers. Why?

In one city requiring all service pipes to be of lead, one-half of all the 2-inch lead services in use have ruptured, and the reason given is the stretching of the walls of the pipe due to frequent increase of pressure. Plumbing is without doubt seriously damaged by change of pressure. Elevated storage reservoirs which serve as equalizers to the pumping rate must be shut off from the distribution system when direct pumping beyond the head produced by the height of the reservoir is required. This seems to be very bad practice, requiring strain and a dangerously high rate of pumping during some fire alarms, which occur at times of heavy domestic consumption.

[1] Manager, Water Company, Davenport, Iowa.

In some cities, mains, of twelve inches diameter and over, have burst during time of carrying fire pressure, virtually putting the water department out of business until such mains were shut off. It sometimes happens that in changing the adjustment of the steam valves on a large pumping engine, to effect a change of water pressure, the pumping engine is accidentally shut down. The writer saw one accident of this kind which resulted in a city of 50,000 population being entirely out of water for nearly half an hour. If there is any time when conditions in the pumping stations should be more free from the danger of accidents than any other time, it is when there is a fire. Increasing pressure for fires is the cause of strain, excitement and, often, accidents that tend to cripple the water department.

A pressure of 60 pounds (138 feet) will supply all but very high buildings with a satisfactory supply for domestic purposes without re-pumping at the building; then, if the mains are of proper size, the fire department can obtain enough water for any fire at good pressure. Such a pressure is ample for automatic sprinklers and is enough for small fires requiring one or two lines of hose.

Ordinarily, firemen do not require more than 40 to 45 pounds pressure at the base of the nozzle. Large fires require more pressure than any ordinary water works can safely carry, because to lay many lines of hose requires some very long lines. Large nozzles require either more than one line of hose to supply them or else high velocities in the hose line and that requires high pressure at the hydrant. Powerful streams require more than 45 pounds at the nozzle.

It should be the duty of the water department to furnish the water in sufficient quantity at ordinary pressures suitable for good domestic service and all higher pressures required should be provided by the fire department using pumpers or fire engines.

The table herewith presented has been prepared from the answers to inquiries sent out to the 143 cities in the United States, having a population of more than 50,000 according to the census of 1920. This table shows that domestic pressures in commercial districts range from 20 pounds to 145 pounds per square inch. Domestic pressures in residential districts range from 25 pounds to 125 pounds. The average reported pressure is, in commercial districts, 68 pounds and in residential districts 56 pounds. Not more than 25 per cent of the cities raise pressure at time of fire.

Table of water pressure in 143 United States cities

City	Normal pressure pounds per square inch: Commercial district	Normal pressure pounds per square inch: Residence district	Pressure increased for fire
Akron, Ohio	35-100	55- 75	None
Albany, N. Y	90	45	None
Allentown, Pa.	50- 55	50	None
Altoona, Pa	65	50	None
Atlanta, Ga	40- 60	60	10 lbs.[a]
Atlantic City, N. J.	40	40	None
Augusta, Ga	70	70	None[b]
Baltimore, Md	40- 80	40-100	None
Bayonne, N. J	60- 70	60- 70	30 lbs.
Berkeley, Cal	35-125	15-175	None
Bethlehem, Pa	64	42	None
Binghampton, N. Y	55- 60	40- 50	10-15 lbs.
Birmingham, Ala	90-100	60- 80	None
Boston, Mass	55- 90	65	None
Bridgeport, Conn	60	50	None
Brockton, Mass	76	70	None
Buffalo, N. Y	50	30- 50	None
Cambridge, Mass	60	60	None
Camden, N. J	35	35	None
Canton, Ohio	65	55	None
Charlestown, S. C	35- 40	35- 40	None
Chattanooga, Tenn	65	45	None
Chester, Pa	79- 90	60- 65	None
Chicago, Ill	30	25	None
Cincinnati, Ohio	50	40	None
Cleveland, Ohio	35- 40	35- 40	None
Columbus, Ohio	57	49	10 lbs. Rarely
Covington, Ky	115	100	None
Dallas, Tex	65	30	None
Davenport, Iowa	60- 65	40-100	20-30 lbs.
Dayton, Ohio	65- 76	50- 70	None
Denver, Colo	55	50	15[c]
Des Moines, Iowa	95	50	15[d]
Detroit, Mich	28- 30	28- 30	None
Duluth, Minn	100	50- 75	None
East Orange, N. J	80	75- 80	None
E. St. Louis, Ill	50	40	None
Elizabeth, N. J	35	30	None
El Paso, Tex	80	60	None
Erie, Pa	65	65	None
Evansville, Ind	50	50	15-40 lbs.
Fall River, Mass	80	30- 55	None

Table of water pressure—Continued

CITY	NORMAL PRESSURE POUNDS PER SQUARE INCH		PRESSURE INCREASED FOR FIRE
	Commercial district	Residence district	
Flint, Mich.	50	50- 65	None
Ft. Wayne, Ind.	40	40	None
Ft. Worth, Tex.	70	25- 40	10 lbs.
Gary, Ind.	55	55	50 lbs.
Grand Rapids, Mich.	60- 90	30- 55	None[e]
Harrisburg, Pa.	70	40- 70	None
Hartford, Conn.	90	90	None
Haverhill, Mass.	38	57	None[f]
Hoboken, N. J.	50	45	50 lbs.
Holyoke, Mass.	65-105	70-110	None
Houston, Tex.	55- 60	50- 55	None
Huntington, W. Va.	90-100	90	None
Indianapolis, Ind.	42	42	30[g]
Jacksonville, Fla.	60	60	40 lbs.
Jersey City, N. J.	45	45	50 lbs.
Johnstown, Pa.	75- 80	60- 70	None[h]
Kansas City, Kans.	90-100	30- 60	10-15 lbs. Rarely
Kansas City, Mo.	100	45	10-15 lbs. Rarely
Knoxville, Tenn.	45	45	50 lbs.
Lancaster, Pa.	55	30- 65	None
Lansing, Mich.	50	40	None[i]
Lawrence, Mass.	67	55- 60	None
Lincoln, Neb.	55- 60	55- 60	50 lbs.
Little Rock, Ark.	65- 95	25- 95	None
Long Beach, Cal.	75	45- 75	None
Louisville, Ky.	75	50	None
Los Angeles, Cal.	40- 70	60	None
Lowell, Mass.	60- 70	40- 60	None
Lynn, Mass.	65	55	None
Macon, Ga.	45- 60	25- 45	None
Manchester, N. H.	60	90	30 lbs.
Memphis, Tenn.	55- 60	50	None
Milwaukee, Wis.	50- 55	25- 50	None
Minneapolis, Minn.	75	60	None
Mobile, Ala.	81	81	None
Nashville, Tenn.	60-100	30- 80	None
Newark, N. J.	30- 70	30- 70	None[i]
New Bedford, Mass.	65- 90	30- 90	None
New Britain, Conn.	25-120	85	None
New Haven, Conn.	40	40	None
New Orleans, La.	60- 70	60- 70	None
New York, N. Y.	50	55	None

Table of water pressure—Continued

City	Normal pressure pounds per square inch		Pressure increased for fire
	Commercial district	Residence district	
Niagara Falls, N. Y.	65– 70	60– 65	40 lbs. Rarely
Norfolk, Va.	30	30	5–10 lbs.
Oakland, Cal.	75	60	None
Oklahoma City, Okla.	70	55– 75	None
Omaha, Neb.	90	60	None
Passaic, N. J.	70 –90	50– 70	None
Patterson, N. J.	60– 70	50– 60	None
Pawtucket, R. I.	90	80– 90	None
Peoria, Ill.	99	48	None
Philadelphia, Pa.	25	25	15 lbs. Rarely
Pittsburgh, Pa.	85– 90	55	None
Portland, Me.	60–100	60	None
Portland, Ore.	80– 90	60	None
Portsmouth, N. H.	60	40	None
Providence, R. I.	64– 72	15– 70	None
Racine, Wis.	60– 70	50	None[k]
Reading, Pa.	30– 66	60	None
Richmond, Va.	20	60	15–25 lbs.[l]
Roanoke, Va.	75	60	None
Rochester, N. Y.	50	50	None
Rockford, Ill.	65	65	15 lbs. Rarely
Sacramento, Cal.	40	40	None
Saginaw, Mich.	45	45	None[k]
St. Joseph, Mo.	90–110	30– 60	10 lbs.
St. Louis, Mo.	50	40	None
St. Paul, Minn.	50– 65	40– 50	None
Salt Lake City, Utah	115	100–125	None
San Antonio, Tex.	70	60	None
San Diego, Cal.	75	50	None
San Francisco, Cal.	50– 60	30– 80	None
Savannah, Ga.	52	52	4 lbs.
Schenectady, N. Y.	85	70	None
Scranton, Pa.	90	80	None[m]
Seattle, Wash.	80-120	40–120	None
Sioux City, Iowa.	87–110	55– 75	15
Somerville, Mass.	60– 95	50– 65	None
South Bend, Ind.	65	55	20–30
Spokane, Wash.	90	70	None
Springfield, Ill.	35– 40	35	None
Springfield, Mass.	140	80	None
Springfield, Ohio.	75	65	None
Syracuse, N. Y.	85– 95	35– 60	None

Table of water pressure—Concluded

CITY	NORMAL PRESSURE POUNDS PER SQUARE INCH		PRESSURE INCREASED FOR FIRE
	Commercial district	Residence district	
Tacoma, Wash.	70	55	None
Tampa, Fla.	58	55	40 lbs.
Terre Haute, Ind.	45– 50	45– 50	55 lbs.
Toledo, Ohio	75	50– 60	None
Topeka, Kans.	60	45	55 lbs.
Trenton, N. J.	40	32	None
Troy, N. Y.	60	60– 80	None
Tulsa, Okla.	60	50	None[m]
Utica, N. Y.	80–125	70	None
Washington, D. C.	30– 50	30– 35	None
Waterbury, N. Y.	110–120	110	None
Wheeling, W. Va.	80– 90	60– 70	None
Wichita, Kans.	50	40	20 lbs.
Wilmington, Del.	32– 64	34– 57	None
Worcester, Mass.	100–145	70–100	None
Yonkers, N. Y.	100–120	60– 90	None[c]
Youngstown, Ohio	100	40	10 lbs.

[a] Increased on special call above 10 pounds.
[b] Increased for very large fire.
[c] In Mercantile District.
[d] In year 1921 raised pressure twice.
[e] In case of large fire an extra pump.
[f] High service in Mercantile District carries 107 pounds.
[g] Are getting away from raising pressure as being dangerous.
[h] Turn on more water to maintain 60 pounds.
[i] Increase on special request of Fire Chief. None in a year.
[j] In some cases maintain minimum of 40 pounds.
[k] Formerly raised pressure—now motorized.
[l] Increased in Mercantile District.
[m] Can raise pressure 15–20 pounds.
[n] Maintains adequate supply—rarely increase pressure.

The amount of the increase of pressure ranges from 4 pounds to 55 pounds. The average is 24 pounds.

In the larger cities such as New York, Philadelphia and Baltimore, high pressure hydrants supplied by separate high pressure mains are available in high value districts and that, of course, is good practice and will doubtless extend to other cities in time.

The Illinois Section of the American Water Works Association, the Indiana Sanitary and Water Supply Association and the Iowa Section of the American Water Works Association have adopted resolutions, which have been published,[2,3] advocating the discontinuance of raising pressure during fires and it is strange that such a reasonable and apparently necessary reform was not started sooner.

[2] See JOURNAL, January, 1922, page 138.
[3] See JOURNAL, July, 1922, page 601.

THE WATER WORKS SUPERINTENDENT[1]

By Edward Bartow[2]

The duties of water works superintendents or managers are so varied that special rules cannot be made to fit all cases. Superintendents of large plants must have many assistants and their work must be primarily that of executives. They must have an accurate general knowledge of the work of the various divisions of water works operation, but they rely on specialists to take immediate charge of the various divisions. On the other hand, superintendents in charge of small plants must take responsibilities for all kinds of work in the plants over which they have control.

Certain duties of water works superintendents again vary in form depending upon whether the plant is owned by a company working under a franchise or whether it is a municipally owned plant operating under the direction of the city government or under a special commission.

In both large and small plants, privately or municipally owned, the primary object of the water works superintendent is to obtain an abundant supply of pure water for all purposes, at all times, and at reasonable rates.

The duties of the superintendent's office of the large water works includes divisions of engineering, records and revenue; and may be sub-divided farther as, for example, into receipt and storage of supplies, pumping, purification and quality control, distribution, extension of system, repairs, maintenance, service connections, meters, accounts, revenue control, applications, extension of customers, consumers accounts, collection of rentals, information, complaints and purchases. Certainly a variety of duties to be under the control of an executive and his assistants or to be under the control of one superintendent in a small plant.

[1] Presidential Address presented before the Philadelphia Convention, May 15, 1922.

[2] Retiring President, American Water Works Association; Professor of Chemistry, Iowa State University, Iowa City, Iowa.

Of primary importance is a complete record of all constructions and all installations. I have seen some small plants in which the records were all in the brain or memory of one man, either because of his inability to keep records or under the mistaken idea that his position would be permanent because no one else could take his place. Under such conditions the reckoning comes for example when an accident occurs that would not have happened or would have been less serious if shut off valves could have been found or possibly when the plant is inspected and no records found. As soon as possible such a man is replaced and someone put in who can and will keep records. Records are of advantage to the man himself in enabling him to serve more efficiently to the board under which he works, when questions of policy have to be decided or for the preparation of the annual budget. They are of special advantage to his successor, who must eventually come, and finally, and perhaps most important, they are of advantage to the people in that they are insured successful and continuous service.

Records, of course, will be of different character and different degrees of completeness. Attempts to set standards are not entirely successful, but there is a certain similarity that allows modifications for special cases, according to the size and conditions of the various plants. Any superintendent who does not have complete and accurate records of locations of mains, valves, hydrants, check valves, etc., should immediately take steps, employing additional help if necessary, to put all of these items on record. There should be complete records of income and outgo. All receipts and expenditures should be carefully accounted for. A carefully kept financial statement appeals to boards who must make appropriations. These appropriations are made with greater understanding and liberality than if an indefinite sum for an indefinite purpose is requested.

Water is an important food and responsibility for its purity has been delegated to the control of state, national and municipal boards of health. A wise superintendent coöperates in every possible manner with the boards of health. One of the best means of co-operation is to support the boards of health in obtaining adequate appropriations and competent personnel.

An efficient board of health can more easily aid the superintendent in obtaining water of high quality. All purification plants for example should be under chemical and bacteriological control at the plant. A board of health laboratory will check the work of the

local laboratory and coöperate in making and keeping the water supply pure. The representatives of the board of health should be looked upon as consultants and advisors, not as policemen.

Many water works superintendents, as individuals, through the Illinois Water Supply Association and its successor, the Illinois Section of the American Water Works Association, were and are of great assistance to the Illinois State Water Survey. As the Water Survey was strengthened by the assistance of the Association, the superintendents in turn received more and better advice and aid from the State Water Survey. The survey has never exercised police power.

The superintendent must maintain coöperation between the water department and the fire department. The fire department is responsible for the extinguishing of fires but is powerless without an abundant supply of water. Preparations to furnish an abundant supply must be included in the plans of a water works system. Few outside persons realize the large part of the total investments in a well designed water works that is required solely to meet the fire demand. The mains must be of sufficient size, proper cross connections must be installed and cut off valves must be properly distributed.

The reservoir must be kept full, with pumping engines in first class condition and all employees of the department ready to assist in case of fire. At many plants a representative of the water department is present at every fire. In case of a second alarm the employees have their special stations. The superintendent goes to the pumping station, the assistant superintendent goes to the fire and other men with automobiles and tools are ready on call in case of breakage of a main or other accidents, so that the service may be interrupted for the shortest possible time. Each man has his place and each knows where the others may be found.

The underwriters in their examination of water plants notes arrangements of this kind and it serves the public by giving it better rates for fire insurance.

In his relations with the public the superintendent must be a diplomat. Nothing should be done, no action taken that will offend the public people, who are directly or indirectly his employers. He must at all times be courteous, and moreover make his assistants courteous. He must see the viewpoint of the other fellow and when complaints are made must do his utmost to remedy any ills, whether real or imaginary.

In order to have satisfactory relations with the public, the relations of the employer and employees must be most cordial and there should be mutual confidence. The superintendent enforces discipline, but in a fair and reasonable manner. There must be an endeavor to serve each other, the public and, in the end, themselves.

All reasonable requests from the public should be granted. If these are unreasonable, the public is entitled to know the reason. It is far better, when necessary to refuse a request, to do so in such a way that there is a satisfied rather than a dissatisfied client. Under such circumstances the company or the department will have the backing of the people.

By various means, the water works superintendent should keep the department before the public. He should remember, first of all that the best advertising is good service.

With good service as a basis, he may get the water department before the public by the publication of readable annual reports, pamphlets on special subjects, by furnishing reading matter or placing formal advertisements in the newspapers.

Mr. S. C. Hadden in our own Journal has made some very good suggestions to members of the Association, concerning publicity. He suggests that the annual report should contain fewer statistics and more readable accounts of the activities of the department, including perhaps special reports made by outside experts, special study and tests by departmental employees, description of problems presenting special difficulties and having somewhat spectacular features, photographs of work finished and under construction, the discussion of the use and abuse of the water system in the home. Matters of this kind will make a report more readable and instructive and would develop the citizens' interest in and appreciation of the water works.

In the interim between annual reports, pamphlets on special topics instructive to readers could be prepared on such subjects as the proper reading of water meters and the making and care of lawns.

The newspapers will accept articles written in popular style. Newspaper editors are willing to publish technical information if it possesses news value. Such use of the newspaper furthers friendly relations between the editor and the water officials. Formal advertising also may be used, either to increase the amount of water sold or to build up good will.

The superintendent should be a member of the local chamber of commerce or commercial club and take part in work for civic improvement. He should be a member of local associations to show his interest in the welfare of the community. He should become identified with state or national water works associations, and should receive the support of his trustees or board in attending these meetings and wherever possible, should see that the board members also attend the convention.

When the superintendent attends association meetings he should not be a mere listener. He should prepare and present papers or, by taking part in discussions, tell his own experiences. The discription of the study and solution of a problem at one plant would be advantageous to all his fellow superintendents.

Several superintendents with similar problems might work together. At one meeting a problem can be outlined, work carried on by correspondence through the year, either informally or by a committee and the results brought together at the next meeting. Thus we may have team work. There is no competition between water companies in different cities nor rivalry for business and he who helps others will find that he is helping himself.

The underwriters in their reports on management of water companies always note whether the manager is connected with associations of water works men. Such connection is an indication of a progressive spirit. The intercourse with other superintendents at meetings and the reading of the proceedings of the association keep the superintendent out of a rut. The abstracts now published in the JOURNAL of the American Water Works Association will show where up-to-date information is obtainable.

Furnishing a satisfactory water supply to a municipality is a legitimate business, and the water company or water department should be so conducted as to show a profit.

The private water company is responsible to the stock holders and should pay interest on bonds and stock, while a municipal water department is responsible to the tax payers and should earn enough to cover all expenses. The details of the business vary in different places and cannot be indicated here, but the superintendent must either be a good accountant or must employ some one who is competent. He must plan his purchases and expenses to keep within his income. The company must depend on his judgement in making purchases and the difference in the cost of coal may mean the difference be-

tween profit and a loss. Economy may be obtained through new installations. The change from out-of-date un-economical machinery to up-to-date economical machinery may make a saving that will pay dividends. The judgment of the superintendent and manager must determine when changes are to be made.

The superintendent should be able to prepare budgets in a practical manner. They should be based on economical operations, but should be sufficient in amount to guarantee satisfactory operation.

The man who undertakes the responsibilities herein outlined ought to be well paid. A city should not employ a superintendent because he will work more cheaply than someone else who is more competent. Training and experience determine a man's qualifications. The salary should be made to fit the position.

The people, who are the real employers of the water works superintendent, employ the best physician available to look after the health of themselves and their children. They employ the best lawyers available to look after the titles of their property and to protect them in legal difficulties. They employ the best architect available to plan their houses or their factories. They should not hire, therefore, a cheap man to look after their water supply, on which in so many ways the health and welfare of the community depend.

The life of the water works superintendent is one of service. His financial rewards should be adequate, but will never be excessive. He cannot expect to become extremely wealthy. His calling is one of the most honorable and he should be proud of it.

Few monuments are built in honor of water works men. Yet every well planned, well operated water works is a monument to the man who successfully constructed and maintained it. I know of only one statue erected in honor of a water works builder, that for D'Arcy at Dijon, France. In that city grateful people have erected a statue and dedicated a park to the honor of the water works builder. Though such cases may be rare, yet in every community where a successful water supply has been obtained and operated, it serves as a monument to its faithful builder and operator.

COÖRDINATION OF WATER AND FIRE DEPARTMENTS' RELATED ACTIVITIES[1]

By Clarence Goldsmith[2]

The general requirements which are imposed upon waterworks systems for adequate and reliable fire service are in the main standardized and well understood by waterworks engineers and superintendents. In order that all the facilities available in both the water and fire departments may function up to as nearly 100 per cent of their ability and capacity during the progress of a fire, it is necessary that the two departments combine their efforts in harmonious action. If this is to be brought about, the heads of each department should make a thorough study together of the many conditions which might arise and formulate definite plans to secure maximum unity in operation before the fire or emergency occurs.

Alarms of fire should sound in some quarters of the water department and a responsible employee familiar with the system should respond to fire alarms in mercantile districts and second alarm elsewhere. An emergency motor-driven truck loaded with necessary tools should be provided for general emergency work and may be used for response to fires as well.

The value of such response should not be underestimated. It is equally important in small as in large cities. In the smaller places the fire department may be mainly or wholly composed of call men or volunteers and frequently, because of lack of training, they do not understand the operation of the hydrants. For instance, a waterworks man can readily place a wrench on a hydrant outlet cap which is stuck and with a sharp kick start the cap, while one inexperienced in such cases could not remove the cap. Cases have been known where firemen did not know in which direction to turn the hydrant stem nut to open the hydrant and broke the stem off by trying to turn it in the wrong direction. Many times it has been found that the foot valve or independent valve on a hose outlet

[1] Read before the meeting of the Illinois Section, March 30, 1922.

[2] Assistant Chief Engineer, The National Board of Fire Underwriters.

has not been opened wide in cases where it was claimed that sufficient pressure at the nozzle or sufficient suction supply to the pumper or steamer was not available. Such a case may be promptly corrected by a waterworks man, provided he is present.

In cases where large service connections enter the building, which is on fire, and these connections serve only domestic and process water, they should be shut off immediately. If such connections serve standpipes or automatic sprinkler equipment, the waterworks representative should find the valve box in the street or sidewalk which controls the connection and be prepared to close the valve in case the chief of the fire department finds that the inside piping system has failed and undue quantities of water are being delivered into the building and not on the fire. It should be remembered always, however, that sprinkler heads operating in the area involved by the fire are delivering water onto the seat of the fire to better advantage than can be done ordinarily by hose streams. The chief of the fire department should ascertain from the water department the approximate quantity of water which the distribution system can deliver into each sprinkler equipment at a pressure sufficient to operate effectively the sprinkler heads at the highest elevation. If this knowledge has been obtained, it will be possible for the fire department to increase the supply where deficient by connecting hose lines from pumpers to the steamer connections of the sprinkler equipment, provided for this purpose. In any case, the rules of the department should require the second hose line laid to be connected to the steamer connection.

Alarms should sound in pumping stations of the direct pumping system. Where pressures are raised to furnish hydrant streams or pumps are started to furnish fire service, duplicate alarm circuits should be provided, as to fire stations. In cities and towns having no fire alarm telegraph systems, dependence has to be placed on the telephone, but this means of transmitting alarms cannot be considered as satisfactory as alarm circuits of the fire alarm system.

In water systems supplied by direct pumpage, it is generally necessary to start additional pumps in case any considerable water is required to extinguish a fire. In small cities and towns the fire flow rate required is considerably in excess of the domestic consumption rate. In a city having 17,000 population, the average domestic consumption rate may be about 1,700,000 gallons, but the required fire flow rate is 5,760,000 gallons. It is readily seen that under such

circumstances it is necessary to increase the rate of pumpage for fires of even moderate proportions. In order to increase the supply promptly upon receipt of an alarm of fire, it is necessary to be able to force the boilers in service and have a sufficient boiler capacity under one-half steam to start additional pumps.

In this connection plans should be made to make major repairs to pumping units during the seasons of the year when domestic demands are at the minimum, so as to maintain as large a pumping capacity in service as possible, taken in relation to the combined domestic and fire demands.

Where pressures are raised for fires, this question assumes greater importance, for the prevailing domestic rate increases somewhat as the pressure is increased. Wherever direct hydrant hose streams are available, it is advisable for the fire department to provide relief valves for each hose line so that when shut-off nozzles are used the possibility of producing damage by water ram may be obviated.

Each fire station should be provided with a map of the water distribution system showing the size of the mains and the location of the hydrants. All firemen should be intimately acquainted with the location of hydrants, particularly in their districts. Commanding officers should have a general knowledge of the sizes of mains so that proper advantage may be taken when two hydrants are equally available and one is supplied from a large main and one from a small main.

Hydrants should be inspected in the spring and fall of each year. The inspection should include the flushing of the hydrant which will test its operation, greasing the hydrant caps, all of which should be removed, and oiling the packing if it needs it. Before the caps are replaced, it should be ascertained that the drain is operative.

There should be enough hydrants installed so that the water required can be concentrated on any group of buildings through hose lines, none of which shall exceed 500 feet in length. Whether the protection is dependent on pumpers or direct hydrant streams, every effort should be made to cut down the friction loss in hose lines.

The waterworks superintendent or engineer is frequently better versed in handling hydraulic problems than the chief of the fire department, and for this reason, he may be of great assistance along this line. For instance, the question of the friction loss in fire hose

can be determined by the following approximate formula: The loss per hundred feet in $2\frac{1}{2}$-inch rubber-lined fire hose in pounds is equal to $2\ q^2$ plus q, where q is the quantity in hundred gallons. The discharge in gallons through nozzles of different sizes when attached to different lengths of hose for the ordinary range of engine and hydrant pressure is given in tables contained in the "Red Book" published by the National Board of Fire Underwriters. Every fire chief should have a copy of this publication and become acquainted with its contents.

Another problem which frequently comes up in connection with hose streams is that of the reaction or pull-back of the playpipe under varying conditions of pressure and size of tips. The pull-back in pounds is $1.5 \times d^2 \times p$ where d is the diameter of the nozzle in inches and p is the pressure at the base of the playpipe.

A few examples of the advantages of coöperation between fire and water departments may not be out of place. In one of our larger cities the fire department had great difficulty in getting horse-drawn steamers up a steep hill, although the hose wagons were generally able to negotitate the run, even with snow and ice on the ground. At the top of this hill there had formerly been a reservoir which was served by a 24-inch line. The reservoir had been abandoned and the large main ordinarily carried about 28 pounds pressure, but the fire department had been waiting until the engines arrived before attempting to get hose streams on fires. The major portion of the buildings were 3-story frame structures which burned rapidly. A conference was held between the engineer of the water-works and the chief of the fire department, which resulted in having two hose wagons go to the top of the hill and it was shown that, by the use of $\frac{3}{4}$-inch tips on the shut-off nozzles, fairly effective fire streams could be thrown without the use of engines.

Weak places in distribution systems and dead ends occur in almost every distribution system. In such cases, where direct hydrant hose streams are depended upon, it frequently happens that the fire department lays out so many lines that none of the hose streams are effective. All such phases should be considered in conference and the fire chief informed of the approximate number of effective streams which can be used at each location.

The water department should have a sample hydrant available so that members of the fire department may be instructed in regard to the mechanical operation of the hydrant, for without such knowledge much serious abuse of hydrants is liable to occur.

Adequate pressures are necessary to furnish the service required. Where fire engines are used, sufficient pressure must be maintained in the mains to overcome the friction loss in the hydrant branches and hydrants and to provide sufficient velocity head to get the required water to the steamer or pumper. Ordinarily 20 pounds in the mains when the maximum fire draft is being drawn is sufficient. There has been a tendency during the past few years, because of the necessity of inaugurating all economies in operation, to reduce pressures on water distribution systems at night. Care should be taken not to reduce pressures to such an extent that existing sprinkler equipments cannot receive a proper supply on the upper line of sprinkler heads. Even where pumpers are used to develop the hose streams, it is important to maintain a moderately high pressure on the mains. The rated capacity of pumpers is based upon a discharge pressure of 120 pounds and where long lines of hose are needed, it is necessary to carry higher discharge pressures, which result in reducing the rated capacity of the pumper, for a pumper will only deliver about one-half its rated capacity at 200 pounds discharge pressure, and only about one-third its rated capacity at 250 pounds pressure. It is readily seen that if 220 pounds discharge pressure were required, and a suction pressure of 100 pounds could be maintained, the pumper could deliver its full rated capacity under these conditions, whereas if the suction pressure were reduced to zero, the capacity of the pumper would be reduced by about one-half.

The operating nuts on hydrants in any city should be of one size. This should include the nuts on the hydrant caps as well as the operating nuts. If brass nuts are on the main stem, they should be looked over carefully at the time of each inspection as they are liable to become so bruised that the hydrant wrench will not fit them.

The hose threads on all hydrants, hose and connections should be of uniform size, preferably that of the national standard hose thread. Where hydrants or hose connections are installed on private property, it is not uncommon to find threads to which the fire department can not connect. It is very desirable that hose threads throughout the country be uniform, and the national board has succeeded in having tools developed by which non-standard hose threads within certain limits can be standardized. The national board has published pamphlets entitled "Standardization of threads for fire hose couplings and fittings" and "Suggested method of procedure for accomplishing the state-wide standardization of threads on fire hose couplings

and fittings." These publications describe the method of handling the standardization problem, and the national board is ready to advise as to the best methods of standardization.

DISCUSSION

D. R. Gwinn:[3] The valuable paper presented by Mr. Goldsmith is of much interest. He has made many valuable suggestions and they are certainly worthy of the consideration of every operating waterworks man.

We, in our city, endeavor to keep in close touch with the chief of the fire department. We try to keep him posted on conditions, especially if there should be any unfavorable ones. We make a point of notifying the chief whenever a hydrant is out of commission due to being broken by automobiles, or when water is shut off in the main for making a connection therewith. He is notified also when the hydrant is again in commission.

A tracing of our pipe system, showing all the fire hydrants, is corrected at the beginning of each year and blue prints made so that every fire house in the city may have a corrected copy. A list of manufacturering concerns having private fire hydrants is included in the tracing. The lines showing the mains are graduated so as to show the relative size.

Several years ago, a number of copies were bought of "Practical Hydraulics for Firemen" by Fred Shepperd. A copy was furnished to each fire house in the city, and an extra copy for the chief and superintendent of the fire alarm system. We also furnished the department with half-tone illustrations showing the length of streams attained through different lengths of fire hose at a given pressure.

We have a Matthew fire hydrant with a side section cut away showing the valve and working parts. Occasionally this hydrant is loaded on our truck and taken around to the different fire houses. Recently, Chief Miller went with our man and at each house he called out the firemen to see the operation of the hydrant. At that time, he stated that the other platoon would be on duty soon in the day time and he wanted us to bring the hydrant around again.

We had a 6-inch main broken under fire pressure some years ago. The result was that the fire got away from the department, as it took some little time to shut out the broken section. It is a serious

[3] President, Water Company, Terre Haute, Indiana.

question whether high pressure should be raised for fires, especially as we now have such well developed pumpers that can furnish adequate pressure.

At the recent meeting of the Indiana Sanitary & Water Supply Association, a resolution was adopted which I think is worthy of consideration by the Illinois Section. The resolution[4] follows:

Whereas, there are serious objections to the practice of raising water pressure on systems of water mains at time of fire, and

Whereas, the increase of pressure in itself results in more water being discharged through the numerous leaks, which always exist and more water being used through fixtures, damage to plumbing, in the breaking of service pipes, and at times, the breaking of large mains; all at a time when the whole water supply should be strictly conserved; and

Whereas, accidents and break downs to pumping machinery and valves are more apt to occur, and do occur, under the additional strain and during the excitement of raising fire pressure; also increased pressure ordinarily requires that water stored in elevated reservoirs is not available during fires because of being shut off to permit direct pumping into the mains so that at such times an extra strain is placed upon filter plants and there is consequent danger of epidemic following a conflagration, and

Whereas, in handling fires in high buildings, and in the case of other serious hazards, fire departments now require large and powerful streams beyond the capacity of domestic water works systems to supply, and

Whereas, such streams can be furnished by motor pumpers which are well adapted to this requirement and make shorter and more lines of hose available without the heavy expense for equipment and operation which was formerly required in the case of steam fire engines.

THEREFORE, BE IT RESOLVED by the Illinois Section of the American Water Works Association in Convention at Champaign, that we recognize the hazard and expense incurred in raising fire pressure in domestic water mains and we declare it is our opinion that this is undesirable practice and that such method of producing fire pressure should be supplanted as rapidly as may be by motor pumper or other auxiliary apparatus as being more suitable, more economical and in the best interest of the whole people.

D. R. GWINN:[3] I move the adoption of this resolution.

F. C. AMSBARY:[5] I second the motion.

The resolution was adopted unanimously.

[4] A similar resolution was adopted at the annual meeting of the Iowa Section, November 2, 1921. See Journal, January, 1922, page 138. [Editor.]

[5] Manager, Water Company, Champaign, Illinois.

CLARENCE GOLDSMITH:[2] I believe that the Underwriters have in many instances the undeserved reputation of trying to get all they can and then trying to get more. The engineering branch of the business with which I am connected stands for the best modern engineering practice, and we are always ready to adjust our views when the evidence is sufficient to warrant. The resolution as presented has much merit, but one thing should be guarded against; pressures should not be reduced to such an extent that they will not be sufficient to supply automatic sprinklers at the elevation of the highest heads; pressures in mercantile districts of 60 to 70 pounds are generally sufficient. About 75 per cent of fires can be extinguished with chemicals, about 20 per cent can be put out with one 2½-inch hose stream, and only about 5 per cent of fires will require the use of pumpers, all provided the above-mentioned pressures are maintained.

OBSERVATIONS ON THE OPERATION OF RAPID SAND FILTER PLANTS[1]

By J. W. Ellms[2]

It is now over thirty years since the Massachusetts State Board of Health began its investigation of the water supplies of Massachusetts. At that time the study of the physical and chemical characteristics of natural waters was regarded as of prime importance, comparatively little attention being paid to their bacteriological content. The microscopical examination of waters for algae, diatoms, protozoa and similar organisms had also been shown to throw considerable light on the quality of surface waters for public supplies. As bacteriological technique was perfected, and as the relation between polluted water and certain diseases became more evident, the examination of waters for the number of bacteria which they contained, together with attempts to isolate certain species of bacteria, came more into vogue.

The early experimental work on the merits of rapid sand filters for purifying public water supplies, carried on at Providence, Louisville, Cincinnati, Pittsburgh, New Orleans and Washington, required the utilization of all the available methods of examination, and as a result of this work analytical methods were much improved, and their interpretative value much better understood. The various kinds of natural waters experimented with in these investigations impressed upon the workers the need for careful standardization of the methods of analysis. This idea took concrete form in the appointment of a committee on this subject by the American Public Health Association. The original work has been revised from time to time, and is at present in process of further revision in order to keep pace with our advance in knowledge on these subjects. In order that this revision of methods may be adequate, the membership of the Committee should be enlarged to include representatives of several of the other national scientific associations, such as the

[1] Read before the Central States Section at Columbus on September 27, 1921.

[2] Consulting Engineer, The Frazier-Ellms-Sheal Company, Cleveland, Ohio.

American and New England Water Works Associations, the American Chemical Society, the American Society of Bacteriologists and the American Society of Microscopists. A revision of these methods by such a committee would be authoritative in the broadest sense, and would establish a firm basis for comparison of results and for interpretation of those results.

The control of the operation of rapid sand filter plants is based largely upon accurate information obtained in the laboratory. If this information is immediately available, so that processes may be modified during the progress of the water through the plant, or if it can only be obtained many hours after the water has been treated, the data secured should be utilized directly or indirectly by the operator in order to guide him in handling the plant. This is much easier said than done, even if we grant the accuracy of the laboratory methods. Facts are of small value unless they are properly interpreted, and unfortunately there is not the consensus of opinion in regard to interpretation even amongst those presumably qualified to express an opinion.

To illustrate conditions commonly met with, we do not agree always upon the merits of fine versus coarse flocculation after treatment with chemicals, upon the proper periods of sedimentation, upon the velocities that may safely be used in conduits, upon the means for preventing incrustation upon filter sands when lime is used, upon the completeness of the precipitation of aluminum hydroxide where alum is employed, upon the size of the sand grains that will produce the greatest bacterial removals, upon the extent to which chlorination of filter effluents may be carried to offset lowered filter efficiency, upon the significance of secondary bacterial growths in settling basins and perhaps filters, upon the weight to be attached to the presence of B. coli, and upon numerous other questions constantly arising from the data that the laboratory produces, and from observation of plant conditions. That waters differ widely in character and consequently in their susceptibility to purification processes is axiomatic. Nevertheless, the most experienced operators are inclined to draw conclusions from too little data and from too limited knowledge of the varied waters which are being purified for public consumption.

It cannot be too strongly stated that many of the fundamentals of rapid sand filter plant control are the result of the accumulated experience of more than twenty-five years' labor in extensive experi-

mental work, costing many thousands of dollars, as well as the practical operation of numerous plants purifying waters of widely varying character. The utilization of new principles which are the result of scientific research, but which have not been tried out on a practical scale, requires caution and an open mind. What may be true under controlled conditions when demonstrated in a laboratory beaker, may be far from true under the conditions existing in a large filter plant. Unforeseen conditions, and factors that cannot be controlled may so modify the original principle that its value for practical purposes is nil.

In spite of the advances made in the art of water purification during the past quarter of a century, no true scientist would claim that the art has been perfected or further progress impossible. The careful scrutiny of all new ideas advanced and their subjection to rigid, practical tests are not only scientific, but wise. The revolutionizing of an art requires the establishing of new principles beyond any question of doubt, and not until this is done may past practices be thrown into the discard.

Water purification in its broadest sense may perhaps include the purification of drinking water, the softening of water for industrial purposes, the disposal of sewage, and the adequate treatment of industrial waste liquors of many kinds. The field for research work is enormous, and the problems involved intricate. There is plenty of room for many workers. If each contributes his mite to the problems presented to him, he will have done his part.

The points I wish to bring out in this paper may be summarized as follows:

1. We must have a set of standard methods of analysis which will be authoritative and adequate for the problems to be solved.

2. We must formulate our problems in such a manner that it is evident to all what the questions at issue are.

3. We must be receptive to new ideas, examining them with candor, neither accepting nor rejecting them without rigid testing.

4. Finally we should hold fast to that which has been established by costly experiments and practical operating conditions, until new methods have demonstrated beyond doubt that something better is possible.

CHLORINATION PRIOR TO FILTRATION[1]

By Norman J. Howard[2]

In Toronto, filtration of City water is effected by means of slow sand and drifting sand systems. The plant is detached from the mainland and situated on an Island, a distance of two miles from the city. The water after filtration flows by gravity to a point one mile north of the works, and then drops down a vertical steel shaft 90 feet deep into a tunnel, and flows by gravity under Toronto Bay to the City where it is chlorinated. The unusual location of the plant and the possibility of leakage between the works and the City, are the chief reasons put forward for not chlorinating the water immediately after filtration.

With the idea of facilitating the operating conditions at the plant, increasing the output, and effecting considerable economy on maintenance and operating costs, the system of chlorination prior to filtration was successfully carried out during the past year. For reasons previously mentioned, no attempt was made to sterilize the water, this being left for final treatment on the City side. Chlorine at the plant was simply applied as an economical and effective substitute for alum, and, as results have shown, has proved entirely successful.

The application of chlorine prior to filtration is a rather radical departure from generally accepted practice in water purification. At the present time considerations based upon theoretical and practical observation, would indicate that chlorine should be applied to water immediately after filtration in order to secure the greatest efficiency. The conservative attitude of the engineering profession, so pronounced a few years ago, was possibly a hindrance to progress in water purification. New departures involving radical changes in established practice, often receive scant consideration and little encouragement. Of recent years the extraordinary advances

[1] Presented before the Chemical and Bacteriological Section at the Philadelphia Convention, May 18, 1922.

[2] Bacteriologist in Charge, Filtration Laboratories, Toronto, Canada.

made in the science of water purification, have proved the value of laboratory control and research. In many instances such work has resulted in the establishment of new theories, which, having been worked out on a practical scale, have resulted in considerable modification of views previously held. As an example of this may be mentioned the sterilization of water supplies, the excess lime method for softening and sterilizing water, the hydrogen-ion theory which is claimed to be the controlling factor in many filtration problems and, more recently, the excess chlorine treatment for the removal of taste and odors.

The drifting sand system of purification as adopted by the City of Toronto must be regarded as a combination of slow sand and mechanical filtration processes, and represents the latest departure from standard systems of water filtration. The plant was designed to operate with applied alum at the rate of 1 grain per gallon, but pollution of the raw water increased at such an abnormal rate, that it was found necessary to apply as much as 2.5 grains per gallon in order to secure a satisfactory effluent. The cost of treating from 35,000,000 to 50,000,000 gallons daily involved an enormous expense, and the high dosage of alum had a tendency to lower the output of the plant. The raw water while being highly polluted at times, does not contain turbidity excepting during storm periods and consequently the application of chlorine either before or after filtration presented no difficulties.

The practice of applying chlorine both before and after filtration is not an appealing one, but the abnormal conditions prevailing in Toronto during the warm weather, when the pumpage rate exceeded 100,000,000 Imperial gallons, have more than justified the action of the City. In connection with these conditions it should be stated that the normal filtering capacity of the plants is approximately 88,000,000 gallons, and, by substituting chlorine for alum, the rate of filtration through the drifting sand plant was increased from 150,000,000 to 175,000,000 Imperial gallons per acre per day, thus yielding additional water at the rate of 10,000,000 gallons per day. The rate of filtration was of course increased only during peak load periods. During the summer months it has been found that a small dose of chlorine was more effective in reducing the bacterial content, than was alumina sulphate, when applied in doses up to 1.5 grains per gallon. In the winter months purification effected by the use of alum compared more favourably with chlorine.

The only objection raised to pre-chlorination was the possibility of taste production, always bearing in mind that the water had to be finally treated on the City side. It must be admitted, particularly in view of the history of taste conditions in Toronto, that the objection was justified. In the first instance it was our intention to apply chlorine and alum alternately, according to prevailing physical and meteorological conditions. This policy was carried out until the months of July and August when chlorine was applied continuously. The water of Lake Ontario is susceptible to taste after chlorination when easterly winds prevail, and at such times, excepting in the months previously mentioned, alum was substituted for chlorine. In the spring and fall the iodoform taste periodically developed, but there is nothing to indicate that pre-chlorination had anything to do with it, as on all occasions, the use of chlorine had been discontinued several hours prior to the taste developing. It is an interesting fact, however, that during the past year taste occurred more frequently than in the previous year when alum was being applied continuously, but the fact remains that no taste occurred in July and August when chlorine only was being applied. Generally speaking during the months of August and September taste often occurs. If it is borne in mind that easterly winds prevailed on 44 per cent of days during August, when chlorine was applied, no taste occurring, and that the dose of chlorine was well above the average in September, due to warm water, the relationship of pre-and final chlorination to taste producing conditions is not apparent. Nevertheless great care was taken to avoid taste, and any unusual conditions at the plant resulted in the temporary discontinuance of chlorine.

PURIFICATION

For the purpose of comparison the average of all results and the purification effected by alum and chlorine separately are given below.

Allowing for the fact that the quality of the raw water was worse when alum was being used, it will be seen throughout the entire tables that the figures after chlorination and filtration, were proportionately better than when alum was being applied. In the month of September, on two occasions when the water was heavily polluted, the dosage of chlorine applied was 0.2 p.p.m. Results showed this amount to have been insufficient, with the quality of the water experienced at the time. If these two results were excluded

from the chlorine figures, the average count on agar would have been reduced from 18.12 to 8.1 per cubic centimeter, rebipelagar figures from 0.44 to 0.25 and the B. coli index from 0.71 to 0.21 per cubic centimeter. The reason for keeping the dosage low was to avoid the possibility of taste, but it is probable that a dose of 0.225

TABLE 1

Bacteria growing on agar at 37°–39°C., twenty-four hours incubation, showing the yearly average number per cubic centimeter, in raw and filtered water and the total percentage reduction in the filtered water for the year

YEARLY AVERAGE		PERCENTAGE REDUCTION
Raw water	Filtered water	
All results included		
566.37	26.29	95.2
When alum alone was being applied		
707.16	44.94	93.6
When chlorine but not alum was being applied		
504.99	18.12	96.3

TABLE 2

Excremental bacteria growing on bile-salt agar (Rebipelagar) at 37–39°C., twenty-four hours incubation, showing the yearly average number per cubic centimeter, in raw and filtered water and the total percentage in the filtered water for the year

YEARLY AVERAGE		PERCENTAGE REDUCTION
Raw water	Filtered water	
All results included		
21.70	1.28	93.8
When alum alone was being applied		
36.03	3.21	91.1
When chlorine but not alum was being applied		
15.45	0.44	96.9

TABLE 3

Indicated number of B. coli per 1 cc. in raw and filtered water and the total percentage reduction in the filtered water for the year

Yearly average		Percentage reduction
Raw water	Filtered water	
All results included		
752.39	1.68	99.8
When alum alone was being applied		
1168.85	3.89	99.6
When chlorine but not alum was being applied		
570.80	0.71	99.9

TABLE 4

	1920		1921
Alum used, 1219.26 tons....	$60,963.00	Alum used, 363.1 tons....	$18,155.00
Chlorine..................		Chlorine 9.373 tons.......	2,343.37
Additional labor...........		Additional labor..........	5,975.32
Total....................	$60,963.00	Total..................	$26,473.69

Note. Alumina sulphate cost $50 per ton delivered to the plant in 1920–1921. Chlorine in 1921 cost $250 per ton. Additional labor included three men working whole time and one relief man two days weekly.

Total expended in chemicals 1920........................	$60,963.00
Total expended in chemicals 1921........................	26,473.69
Net saving..	$34,489.31

The average dose of applied alum in 1920 was 1.219 grains per Imperial gallon, while in 1921 it was 1.30 grains. During 1921 the average amount of water filtered through the drifting sand plant was slightly lower than in 1920. This latter difference was balanced by the increased dosage of alum during the past year.

By utilizing the services of the chlorine operators on the plant during such times as the chlorine was not being applied, and by saving in pumpage and backwash water, etc., the superintendant of the plant has estimated a further saving of $5000 during the year 1921, making a total saving of $39,489.31.

could have been safely maintained as at this particular time no taste developed.

In connection with the purification figures two important conditions are involved, firstly that alum was applied at the approximate rate of one grain per gallon excepting during storm and turbid water conditions, clarification of the water being regarded as the first consideration, and secondly no attempt was made to sterilize the water, sufficient chlorine only being added to greatly improve the quality of the effluent. The reason for this latter condition, as has already been stated, was that chlorine was finally applied on the City side.

ECONOMY EFFECTED

The basis for comparison of operating costs of applied chemicals is taken between the years 1920 and 1921. In the former year alum was applied throughout, while in 1921 chlorine and alum were applied alternately.

The question of taste has already been discussed, but it should be mentioned that, when chlorine was applied in amounts varying between 0.150 and 0.3 p.p.m., excess chlorine was entirely absorbed in the drifting sand filters, that is to say tests with starch and iodide indicated its absence. In connection with excess chlorine treatment for eliminating taste, and where pre-chlorination is practicable, the removal of excess chlorine by filtration is worthy of consideration.

From the forgoing facts and figures presented it will be seen that where conditions are suitable chlorination prior to mechanical filtration is a sound and economical method of operation, the advantages claimed being:

1. Purer water obtained.
2. Great economy effected.
3. Operation of plant generally facilitated.
4. Increased rate of filtration possible.
5. Probable removal of chlorine taste.

DOES BILE INHIBIT OR STIMULATE GROWTH OF THE COLON GROUP?[1]

By Max Levine[2]

When in 1906 Jackson suggested the use of lactose bile for isolation of the colon group, it was enthusiastically received by water analysts, for its superiority to glucose broth as a presumptive test was distinctly manifest, and in 1912 bile was adopted by the Committee on Standard Methods of Water Analysis.

The medium recommended consisted of undiluted ox bile (or 10 per cent dried bile) to which was added 1 per cent peptone and 1 per cent lactose. That this medium inhibited the growth of some strains of the colon group was clearly recognized by the Committee who believed, however, that only the attenuated or weakened individuals were affected and that consequently this selective antiseptic action was an added advantage. Thus they state, "Attenuated B. coli does not represent recent contamination and all B. coli not attenuated grow readily in lactose bile." . . . . "In the interpretation of the sanitary quality of a water it is best to discount the presence of attenuated B. coli and to be sure to obtain all vigorous types. The lactose bile medium accomplishes both these objects."

In 1913, Jordan, after a careful investigation, concluded that there is no relation between attenuation and the antiseptic action of the bile. He found that freshly isolated strains were inhibited to as great or ever a greater degree than old cultures. Cumming, in a comparison of lactose bile and lactose broth, records that with sewage preliminary enrichment in the former yielded only 25 per cent as many colon forms as were obtained with lactose broth, and that a similar study, with river water, gave only 50 to 70 per cent as many colon organisms as was obtained with the broth. From his study on the Potomac River, Cumming concludes that about

[1] Read before the Iowa Section meeting, Omaha, November 1, 1921.

[2] Associate Professor of Bacteriology and Bacteriologist Engineering Experiment Station, Ames, Iowa.

one-half of the colon bacilli were lost when the bile medium was employed for preliminary enrichment. Obst obtained similar results.

In consequence of these reports the 1917 Standard Methods recommend lactose broth for preliminary enrichment and the presumptive test.

Opposed to the views expressed above is that of Hale who maintains that the bile medium is far superior, that formation of gas was more rapid, produced in larger amounts and that the anaerobic spore-formers (Cl. welchii) were less frequent. In a discussion of a paper by Winslow 1916, Hale states as follows:

> Since the Committee on the Revision of Standard Methods has advocated the use of lactose broth we have again made at Mount Prospect Laboratory a series of comparisons with the lactose bile and lactose broth, confirming by litmus lactose agar. The broth was made as recommended by the committee; the bile was 5 per cent as recently recommended from this laboratory. The results were all in favor of bile, quicker gas formation, gas in larger amounts, and less B. welchii forms. In one day the results with bile were practically equal to those obtained in two days with the broth.

Thus the question has been raised as to whether bile inhibits or stimulates growth of the colon group. The author felt that this query might be adequately answered and the supposedly conflicting views of Jordan and Hale reconciled by a study of the effect of various concentrations of bile. In this connection it should be pointed out that whereas Jordan, Obst and Cumming used the original whole (or 10 per cent dried) bile medium, Hale has decreased the concentration to 5 per cent dried bile.

The following report deals with the effect of various quantities of sodium taurocholate (Merck) and evaporated bile (Difco) on the rate of multiplication of Bact. coli and Bact. aerogenes.

The method of study was to inoculate $\frac{1}{100,000}$ cc. of a twenty-four-hour peptone culture into 10 cc. of 0.5 per cent peptone water containing definite concentrations of dried bile or sodium taurocholate, and after seven hours' incubation in a water bath at 37°C. to determine the number of viable cells by planting on agar (37°C.—forty-eight hours). The results are indicated in the following tables.

It is apparent that for both Bact. coli and Bact. aerogenes there exists an optimum concentration of bile constituents. Sodium taurocholate up to 1.5 per cent accelerated growth of Bact. aerogenes; the maximum count being obtained with a concentration of 0.75 per

TABLE 1

Effect of concentration of sodium taurocholate (Merck) on the growth of Bact. aerogenes in 0.5 per cent peptone (Difco)

TIME	PER CENT OF SODIUM TAUROCHOLATE	AVERAGE NUMBER BACTERIA PER CUBIC CENTIMETER	GENERATION TIME
	Series no. 1		
minutes			*minutes*
0		206	
420	0 (Control)	605,000	36.4
420	0.25	2,120,000	31.5
420	0.5	3,165,000	30.2
420	0.75	4,300,000	29.1
420	1.0	4,150,000	29.3
420	1.5	3,100,000	30.2
	Series no. 2		
0		223	33.0
420	0 (Control)	1,490,000	33.1
420	0.25	1,425,000	33.2
420	0.5	1,540,000	32.9
420	0.75	2,830,000	30.8
420	1.0	2,450,000	31.3
420	1.5	2,260,000	31.5

TABLE 2

Effect of concentration of sodium taurocholate (Merck) on the growth of Bact. coli in 0.5 per cent peptone (Difco)

TIME	PER CENT OF SODIUM TAUROCHOLATE	AVERAGE NUMBER BACTERIA PER CUBIC CENTIMETER	GENERATION TIME
	Series no. 1		
minutes			*minutes*
0		255	
420	0 (Control)	1,240,000	34.2
420	0.25	980,000	35.2
420	0.5	1,780,000	32.9
420	0.75	1,582,000	33.3
420	1.0	1,390,000	33.8
420	1.5	220,000	43.1
	Series no. 2		
0		235	
420	0 (Control)	460,000	38.4
420	0.25	4,150,000	29.7
420	0.5	4,020.000	29.8
420	0.75	4,635,000	29.4
420	1.0	4,330,000	29.6
420	1.5	3,940,000	29.9

TABLE 3

Effect of concentration of evaporated bile (Difco) on the growth of Bact. aerogenes in 0.5 per cent peptone

TIME	PER CENT BILE	AVERAGE NUMBER BACTERIA PER CUBIC CENTIMETER	GENERATION TIME
Series no. 1			
minutes			*minutes*
0		112	
420	0 (Control)	1,300,000	31.1
420	0.5	2,145,000	29.5
420	1.0	2,450,000	29.1
420	2.0	820,000	32.7
420	5.0	230,000	38.1
420	10.0	9,000	66.3
Series no. 2			
0		136	
420	0 (Control)	642,500	34.4
420	0.5	715,000	33.9
420	1.0	930,000	32.9
420	2.0	595,000	34.7
420	5.0	307,000	37.6
420	10.0	1,300	128.9

TABLE 4

Effect of concentration of evaporated bile (Difco) on the growth of Bact. coli in 0.5 per cent peptone

TIME	PER CENT BILE	AVERAGE NUMBER BACTERIA PER CUBIC CENTIMETER	GENERATION TIME
Series no. 1			
minutes			*minutes*
0		222	
420	0 (Control)	3,240,000	41.7
420	0.5	6,675,000	38.7
420	1.0	8,350,000	37.8
420	2.0	8,050,000	27.7
420	5.0	1,000,000	32.2
420	10.0	280,000	41.8
Series no. 2			
0		252	
420	0 (Control)	3,200,000	30.8
420	0.5	6,070,000	28.8
420	1.0	8,450,000	27.9
420	2.0	8,950,000	27.7
420	5.0	1,900,000	32.6
420	10.0	280,000	41.2

cent of the salt. Similar (though more irregular) results were obtained with Bact. coli.

The effect of Difco evaporated bile was particularly marked and distinct. The maximum count of Bact. aerogenes was obtained with a concentration of 1 per cent dried bile. Higher concentrations were distinctly inhibitory. Thus in the presence of 10 per cent dried bile, which was the medium originally recommended, the count was only a fraction of a per cent of that obtained with peptone water alone.

Bact. coli grew best in the presence of 2 per cent evaporated bile and the concentration of even 5 per cent was not detrimental but 10 per cent was markedly inhibitory.

In conclusion, it may be said that the value of bile media in routine water analyses is still an open question and needs further careful study. From the results here presented it seems that the inclusion of a small quantity of dried bile (1 to 2 per cent) for preliminary enrichment and presumptive test media for the colon group would be highly desirable. For comparable results a standard evaporated bile or pure bile salts are of course essential. The advantages of such a medium are (1) growth of Bact. coli and Bact. aerogenes is accelerated, (2) many of the anaerobic spore-forming lactose-fermenters are inhibited and (3) the sporing lactose fermenters, capable of growing aerobically, do not grow in peptone lactose bile.

The writer desires to express his thanks and appreciation to Miss Dorothy Bowdish, a part of whose work is the basis for this paper.

OFFICE RECORDS AND ACCOUNTING[1]

W. E. Lautz:[2] In the matter of collections for water service and billing the consumer there seems to be no uniformity of practice in water companies, departments or other utilities.

Our service is 100 per cent metered. We bill on a quarterly basis, except for the larger consumers, comprising about 4 per cent of the total number of services, which are billed monthly. Postal card notices for the amounts due are sent out to the consumers. A separate bill is made out for each service. The bill is retained at the office. The consumer is billed at the net amount which must be paid within ten days or a 10 per cent penalty is added. About 97 per cent of our consumers pay their accounts within the ten-day period. When the consumer pays the bill, he is given a receipt which shows both readings, the consumption during the billing period and the amount due. A stub is retained from each bill from which the proper posting is made direct to the consumer's ledger account.

The local gas and electric company bill their consumers monthly. The bills are distributed by private carrier. The stub of each bill is detached and retained at the office. The consumer is expected to return the bill to be receipted when payment is made at the office.

The local telephone company bills its consumers monthly. The bills are distributed by private carrier. The distributor endeavors to collect the bill on presentation. I understand that the collector makes but one call. If payment is not made to the collector, the bill is left with the customer and the customer is expected to return the bill and make payment of the amount due at the company's office within the discount period.

Some companies use the post card form of bill, others distribute their bills by private carrier. Some send out a collector, others, require all payments to be made at the office. Some bill monthly, others bill quarterly except for their large consumers. It would be interesting as well as valuable to find out and bring before this meeting something of the different practices in the various cities here represented.

[1] Discussion at the Illinois Section meeting, March 30, 1922.

[2] Secretary and Manager, Pekin Water Works, Pekin, Ill.

F. C. Amsbary:[3] We collect quarterly. We mail a postcard showing the rates for the water all figured out in number of gallons used. That bill is mailed and must be paid within ten days or ten per cent is added. There is a slight difference (no difference at all in fact) but there appears to be a difference in charging a penalty of 10 per cent or giving a discount. The customer does not like the idea of paying a penalty. We regretted that 10 per cent penalty, but we do not have much trouble in that way. Often they come into the office without their card, perhaps 10 per cent of them do this, and in that event we have blank cards which are marked "received of ——— for water, from ———." We do not put in all the meter readings or rates. That would take up too much time. We are going to put in effect before long, a system of zoning. This will mean a system of continual billing. The office force will then have steady work, not some days of overwork and then underwork the rest of the time.

R. D. Huggans:[4] Our flat rate consumers pay every three months, in advance. They are notified at the beginning of a quarter, through the newspapers, that their accounts are due and that they should be paid by such and such a date. Our meter accounts are billed every month. We make out the bills and have the carriers distribute them. It is cheaper at $1\frac{1}{4}$ cents to have them delivered by carrier than to pay 2 cents to have them mailed. One man does all of the meter reading and it takes him practically the whole month to get over the ground.

Question: How many meters have you?

R. D. Huggans:[4] About 2500, but a good many of them are outside meters. It takes longer to read these than inside meters, especially in winter months. The reason it takes him this length of time is that we usually go back, when people are not at home, where meters are inside.

D. R. Gwinn:[5] First of all I was impressed by what Mr. McDonald said about the charge for service and not for the water. It reminded

[3] Manager, Water Company, Champaign, Ill.
[4] Manager, Water Works, Streator, Ill.
[5] President, Water Company, Terre Haute, Ind.

me of the old colored man. The minister asked him for a contribution. "Why, I thought that this here religion was free," he said. "Well it is," the preacher told him, "but you have to pay for the pipes." That is about the case with us. We have to have the water coagulated, settled, filtered, sterilized, and pump it twice most of the time. Mr. McDonald told me several years ago about his scheme. I wondered if I could adopt it for our use, but I could not see any way in which it would work without indexes. We have about 8800 metered accounts and 125 flat rates. Meter rates are collected monthly and the flat rates quarterly. Our ledgers are arranged according to streets so that the clerks can locate any account by reference to the street in the ledger. We save a lot of time by doing this. We have about six men who read meters. They do the reading about the 21st of the month. Bills are delivered on the 31st of the month. After the meter reading book is returned to the office the clerk takes that book and enters the reading in the ledger, makes the subtraction and enters the amount due; then that operation is finished. The next clerk picks up the ledger and makes out the bill, so far as the readings and cubic feet used are concerned. Then another clerk finishes the bills, using system of rubber stamps showing the different number of cubic feet and what they amount to. The bills are all compared before they go out of the office by the secretary or the assistant manager. These bills are arranged in routes. On the last day of the month we take all the help we can spare out of the office and a number of others and send the bills out. If the consumer desires, he may pay the amount of the bill and we find that many of our consumers want to do this. The majority of women in fact would rather have this system, as they are busy with their household duties and children and do not have time to come down to the office to pay their bills. About 40 per cent of our bills are paid in that way. Of course we always have a few delinquents. But I might say that invariably they are always the same ones. About the 8th of the month we take about a 60-inch space in each of the daily papers accouncing that the water bills that were due on the last day of the month should be paid by the 10th. Of course, you cannot account for those people who never will learn to pay their bills. We pay the collectors $3.50 a day. Most of them are ladies, who are not busy at home. We have never lost money through the failure to turn in cash. Occasionally they come in short and once in awhile they come in long and then

we have some trouble finding the party who paid the bill. We have used this plan for about five or six years.

E. MacDonald:[6] I would like to say a few things regarding the rubber stamp method. We thought very earnestly about that. Ordinarily with simply a water plant such as Mr. Gwinn has, it is I presume the best method; but we have such a complicated mixture of accounts, we found that it would take an enormous amount of rubber stamps. I made an estimate at one time of the number of stamps it would take and you would hardly believe me if I would tell you the number I estimated.

As far as the index feature is concerned we have no index. In order to start this new system we threw away previous ledgers. For instance Kickapoo Street is the longest street in our town, but it does not appear in our ledgers excepting as it appears one block at a time in connection with the intersecting streets running east and west. Our clerks soon became accustomed to the system, so that if they would name some certain street number they could tell us without a moment's hesitation where that was located. If a customer should come in without his bill but would give his street number the clerks without any difficulty could go to the ledger and get the account. This system bothered our clerks a little for perhaps two months, but in that length of time they became so accustomed to it that they needed no index whatever.

P. Barnhard:[7] We have three departments like Mr. MacDonald but no ledgers or indexes. We have thrown away our pen and our rubber stamps. Like Mr. MacDonald, we use different colored paper to represent the several departments. Our bill forms are made out on the typewriter in triplicate, the original being sent to the customer, the duplicate placed in the customer's file and the triplicate bound in a book. The total forms our accounts receivable, and is the only entry carried to our general ledger. When the customer comes in to pay his bill, should he be without the statement sent him, we simply look in his folder which is filed alphabetically and are able to make out a duplicate bill for his receipt. As the bills are paid, they are taken out of one folder and filed away in the customer's paid folder and are kept for inspection of the Public

[6] Manager, Water and Light Company, Lincoln, Ill.
[7] Manager, Mount Carmel Public Utility Company, Mt. Carmel, Ill.

Utilities Commission. The Commission requires that these bills be kept for three years. We find this is convenient, for when a customer complains of his bills running higher than usual, with all of the several years' bills before us, we are enabled to make comparison. We usually are able to convince him from the record that his bill is no higher than for the corresponding month the year before.

WM. MOLIS:[8] I presume according to these discussions that all of your consumers pay their bills. Well, they don't in our town. But if they don't, off they go. We may seem to lose some of them for a time, but they come back again the first of the month.

If the bills are not paid by the tenth of the month they lose the discount which is ten per cent, and if not paid by the 15th, 25 cents is added for collection, and if not paid by the 20th, the service is cut off.

Usually the ones which are cut off are the first to pay next month. We charge $1.00 for turning on the water, when the water has been turned off for non payment.

We charge the account to the property owner and it is a lien on the property. They must sign such a contract when making application for water.

[8] Superintendent, Water Works, Muscatine, Iowa.

EXPERIENCES WITH ALGAE AT DAVENPORT

By Charles R. Henderson[1]

During July, 1921, the filtered water at the Davenport Water Works was unsatisfactory. The number of bacteria was high and there was more than one positive test for gas formers in five 10-cc. samples tested. Mississippi River is the source of the water. 3.78 grains of alumina per gallon were applied to the raw water, which had a turbidity of 150 parts per million. The water, after treatment with alum, passed through an uncovered concrete settling basin having a sufficient capacity to contain 24 hours flow. 0.74 part per million of chlorine was applied to the settled water before filtration through pressure filters.

Owing to unfavorable conditions the basins had not been cleaned since early spring. On the supposition that the uncleaned basins were the cause of the trouble the basins were cleaned, but without improving the bacteriological conditions of the water. Microscopic examination of the raw water showed vast quantities of algae, "melosira." No tastes or odors accompanied the poor bacteriological condition.

Copper sulphate applied to the water entering the settling basin gave no improvement. There was some clogging of the filter beds but not to a serious extent. As a final remedy the amount of liquid chlorine was increased. To do this it was necessary to increase the capacity of the chlorine apparatus. Half-hourly tests of residual chlorine in the water applied to the filters were made by the potassium iodide starch method. The amount of chlorine was increased by steps until eighteen pounds per million gallons or 2.16 parts per million was used. With this amount of chlorine no residual chlorine was noted in the filtered water when used in any quantity below the maximum, and there was no complaint of tastes or odors in the water delivered to the city. After the algae disappeared from the raw water, sharp reductions in the amount of chlorine used were necessary until the quantity of 4 pounds per million gallons was reached in December, 1921.

[1]Manager, Water Company, Davenport, Iowa.

In August, 1921, trouble of an entirely different character occurred in the open 5,000,000-gallon capacity filtered water storage reservoir of the Davenport Water Company. A heavy growth of oscillaria developed. An attempt to control the growth by spraying the inside slope and the water around the edge of the reservoir, where the most active growth appeared to be, failed. By this time the odor and taste had become very objectionable and the neighbors were demanding that the reservoir be emptied and cleaned, on the theory that a bad smell meant unclean conditions. The reservoir was emptied and cleaned, in order to satisfy this public clamor. After the reservoir was emptied the slopes and bottom were washed with hose streams and cleaned with brooms. Calcium hypo-chlorite was sprinkled over the entire bottom and the reservoir again washed. Soon after the reservoir was filled with water, algae reappeared. Spraying along the edges was ineffective, and it was not until the whole body of water was treated with copper sulphate by dragging a bag of copper sulphate attached to a float back and forth across the reservoir, that the algae disappeared.

After the whole body was treated with the copper sulphate, the algae disappeared, and no more trouble was experienced during the fall.

WATER WASTE[1]

By A. E. Skinner[2]

Water waste is money waste because money necessarily must be expended in the collection, purification and distribution of water. The greater the water waste, the greater is the money waste in building larger dams and reservoirs, erecting larger filtration plants, effecting more chlorination, and installing larger pumps and pipe lines than actually are required.

The term water waste is applied to non-revenue producing water and is caused by waste from leaks of mains and services, house waste due to leaking plumbing fixtures, under-registration of meters, and the illegal use of water through fire lines or other means.

The importance of preventing water waste has been impressed forcibly upon water works officials due to the recent greatly increased production cost of water. Since it costs as much to produce waste water, or non-revenue producing water, as it does to produce consumed water, or revenue producing water, you can readily see that water waste being a money waste acts as a continuous financial drain on the resources of the water department.

Accordingly it may be of interest for the members of the Illinois Section to know of the method whereby one may quickly decrease operating costs and increase revenue by stopping the waste of water.

The method used successfully during the past twenty-five years in over three hundred cities in this country is called a Pitometer water waste survey. Such a survey accounts for the water supplied to the distribution system from the pumping station or from the reservoirs, as the case may be. In this accounting there necessarily is found the waste water which is part of the total amount supplied to the system.

A survey is started by measuring the total daily consumption supplied to the city. If this measurement is made at a pumping station, the pumps also are tested for slip or capacity. Some pump

[1] Read before the meeting of the Illinois Section, March 30, 1922.

[2] Western Manager, The Pitometer Company, New York and Chicago.

tests have shown that the pumps were actually discharging one-half of their theoretical discharge.

The next step in a water waste survey is to divide the distribution system into districts and to measure the flow of water into each district throughout the twenty-four hours. A district is established by closing tightly the boundary valves in the system, thus segregating it from the rest of the system. The district is supplied with water through one main and a Pitometer is installed at a gauging point on that main. Then all the water used in the district under test is now measured for a period of at least twenty-four hours. From this continuous twenty-four hour record, the average daily consumption and the minimum night rate of flow of the district are obtained. If a district under test has no metered manufacturing consumption in it at night, to account satisfactorily for the night rate found between 1:00 a.m. and 4:00 a.m., it is necessary to investigate further to determine what causes the night rate.

Accordingly working at night the district is closed in again as described before and the Pitometer measures the flow into the district. By the proper operation of the valves within the district the flow between valves is measured and recorded on the Pitometer. Then obtaining a rate of flow on a main between certain valves, it becomes rather easy to trace this rate down to the particular point at which it occurs between the valves. The waste from this particular point is stopped and the saving is made permanent.

From this method as described, you will note that the only part of the system that is investigated is that which needs investigation, attention and correction as shown by the actual measurements of flow of water into that part.

Another feature of a Pitometer survey is the check on the large consumers for the illegal use of water through fire lines or by various ingenious methods. It is surprising how many large consumers favor free water. A number of cases might be cited where the back water bills based on the Pitometer measurements have covered many times the cost of the survey.

During the survey tests are made of all large meters in place for under-registration which is caused by the improper selection, installation and care of the meters. The correction of the under-registration of the large meters greatly increases the revenue of the water department. Most departments are handicapped by not having means of testing their large meters under actual service conditions

and a Pitometer will quickly and accurately give the department the information needed.

Incidentally in the routine work of a survey many conditions unknown to the officials are discovered such as the location of mains and valves, some of which exist and others do not, the finding of broken or closed valves which affect the repairs and pressures of a distribution system, and the measurement of consumption in various sections, which aids in the planning of re-inforcements to the system. In fact, in some cities a Pitometer water waste survey has postponed the need for new equipment or extensions by the elimination of the waste water.

ANNUAL REPORT OF THE PUBLICATION COMMITTEE[1]

The Publication Committee has undertaken this year the preparation of a convention program which to many of the members might require some explanation. At various times suggestions are forwarded to the Committee to establish programs to be made up of papers dealing with one type of subject, to provide short papers on many different topics, short meetings and long meetings, sessions with time limits on papers, separate meetings for different sections, and joint hearings for different groups. Obviously no program could fulfill all of these requirements. For this reason, the Committee has held several consultations and exchanged much correspondence in order to formulate a logical and, it is hoped, an interesting series of papers. It is too early to determine the success of its plan, but this occasion warrants at least the presentation of the kind of program placed before you. It is experimental and, like most experiments, succeeds or fails not only of itself but because of its environment.

The program is intentionally a long one, not to try your patience but to appease your appetite for information. The technical features of the sessions are serious in content and it was believed that most of the members would be willing and able to spend an additional day if a fair return were promised. By lengthening the program it is possible also to eliminate to a degree the conflict in papers between the general sessions and those of the chemical and bacteriological section. It has appeared for some years that the holding of these meetings in parallel, made necessary by a short convention, results in a loss to many members. This conflict has been avoided as far as practicable, on the hypothesis that the interest of a large proportion of the membership extends broadly, if not intimately, beyond the scope of daily duties.

It should not be ignored, also, that a long convention with many papers, in general, will attract a greater attendance than a shorter one with a few papers, no matter how carefully these may be selected. The chance of striking each member's interest somewhere through many papers is manifestly far greater than with few topics, and the

[1] Presented before the Philadelphia Convention, May 16, 1922.

full program, even though unwieldy, is useful as a persuader in the production of public funds for many a trip to the convention.

A conscious attempt has been made to vary the subject matter of papers at any one session. Here again it has been assumed that variety will hold interest, even though strict logic would suggest concentration of papers on the same or similar topics to single sessions. The Committee has agreed that a convention cannot be arranged as rigidly as a board meeting. The successful appeal of the program was the dominating thought responsible for the length of the proceedings, the avoidance of conflicting sessions, the reduction of symposia, the variety of topics at each session, and the inclusion of many papers. Whether or not the Committee has acted wisely remains to be seen. At any rate, the test of this year may guide its successors.

This year has marked a transition period in the progress of the JOURNAL, due to the change in editorial supervision which took place last July. Since the former editor had established certain policies of publication, which were familiar already to our members, it was possible for the new editor to embark upon his program with no friction. This condition in turn was responsible for the fact that few papers were presented before the Committee for settling controversial points as to publication. In these few instances the constitutional requirements were so obviously contravened that decisions were not difficult or contested. It is gratifying to report that the calibre of articles being submitted is steadily attaining a higher grade, in a literary, practical and scientific sense.

During the past fiscal year a budget of $8000 was allowed for printing the JOURNAL. Of this fund, over $800 remained unexpended at the end of the fiscal year. This saving is due to slight reductions in certain printing charges, to a change of policy in the routine handling of proofs, and to the fact that the September, November and January issues, at the end of the last fiscal year, were in total of smaller size than usual. This last reduction had its origin in the fact that the new editor was entering upon a gradual expansion of the paper, rather than upon an abrupt expenditure of funds before familiarizing himself with the details of the publication costs.

In the succeeding year the budget should be at least $8000 and if possible more, in order to provide for expansion in several directions which the Committee will indicate. If the abstracts section of the JOURNAL is to be developed to its maximum advantage, more

funds will be necessary for its printing, since the set-up of this part of the JOURNAL is more expensive proportionately than that of the remainder. It is felt, however, that this recent innovation is of such value that additional expenditures are warranted.

Since the JOURNAL represents probably the most effective connecting link among all the members, considerable thought has been given to the desirability of its expansion. The conclusion seems obvious that this publication should be something more than the mere repository of papers presented before our various society meetings. The number of original papers, not presented or printed elsewhere, might well be increased. The only limitation appears to be the expense, for it is possible to increase considerably the number of papers offered for publication. It should be pointed out that previous Committees have recognized also the advantage of extending the amount of original material appearing in the JOURNAL.

It has been suggested to the Committee that more book reviews should appear. Here again, as in other directions, extension of the scope of the publication waits upon increased funds. These future prospects are, therefore, in the hands of the members. The JOURNAL may be expanded with profit, if this be the wish of the Association.

Some detailed reference should be made to the policy of determining upon the complexion of the subject matter which appears in the JOURNAL. The greater part of material is not subject to selection by the editor, for it represents papers, reports, discussions, etc., which have been presented before the parent body or the sections. Probably less than 10 per cent of the printed matter can be selected. The nature of this material is determined as far as is practicable by the distribution of our membership. For editorial guidance, the total active membership of 1326, on our books in September, 1921, has been classified as follows:

Distribution of active membership, total 1326

	ENGINEERS, CIVIL, SANITARY, HYDRAULIC, ETC.	SUPERINTENDENTS	EXECUTIVES, MANAGERS, ETC.	CHEMISTS, BACTERIOLOGISTS	UNCLASSIFIED	TOTAL
Number....	569	288	248	87	134	1326
Per cent....	43	22	18	6	10	100

It is interesting to note that the membership is not restricted to any particular class, making allowances, of course, for overlappings

which must appear in any such classification as the above. Close adherence to a distribution of subject matter strictly in accordance with rigid membership classification is manifestly impossible. Such distribution of members is of interest and value, however, to indicate that published material cannot be restricted to meet at all times the single individual's needs. It is agreed, on the other hand, that emphasis should be shifted to those papers which would be most helpful to the members needing most help, even though such a plan would result in upsetting somewhat the balance. The reason for introducing the classification of members is to keep before us, in a general manner, the fact that the organization has many viewpoints. Perhaps some individuals do not always keep this fact in mind when criticizing the JOURNAL.

The question is frequently raised as to the failure to report fully the discussions taking place at the convention and at section meetings. Where such omissions occur the responsibility more often rests upon the members themselves, who, on re-reading the typewritten minutes of their remarks, inform us that they never said such things, or they have changed their opinions, or they do not believe the material is worth publishing. Most of us would agree, no doubt, that jokes are interesting on the floor of the meetings, but few would care to expend dollars on their publication in the JOURNAL. Yet it is surprising what proportion of the minutes of meetings consists of jokes, many of them good, but not all. A serious effort is made to include such discussions as are useful, accurate and interesting. When they do not appear, something more than editorial bias should be charged with the omissions.

This report should not be closed without emphatic reference to a defect in JOURNAL content which the entire Committee recognizes and which it is difficult to remedy. A certain part of our membership is made up of water works men, highly practical and efficient, but untrained perhaps in the more technical branches of their work. These men need help in their daily work. Articles of a peculiarly practical type are necessary for their development, yet such papers are most difficult to obtain. The kind of person who has such valuable information is often too busy, too modest, or too unconcerned with his fellow man to present it for publication. It is to this class of membership that the Committee particularly appeals for aid, but it cannot refrain from adding the injunction that real assistance from the JOURNAL must depend upon the initiative

of this group of members. Only too often does complaint arise from men who do little or nothing to contribute their experience for the welfare of their fellows. The Committee hopes for greater coöperation from the water works superintendent, who knows but sometimes will not tell.

Robert B. Morse, *Chairman*,
William W. Brush,
Harry E. Jordan,
Seth M. Van Loan,
Abel Wolman, *Editor*.

REPORT OF THE COUNCIL ON STANDARDIZATION[1]

The Council on Standardization has proceeded actively, along the lines set forth in its report[2] of June, 1921, with its 17 committees in which a few changes in the personnel have been made.

Reports at this meeting will be made by the following committees:

Industrial Wastes in Relation to Water Supply
Water Shed Protection
Standard Specifications for Cast Iron Pipe and Specials
Physical Standards for Distribution Systems
Meter Schedules
Standard Methods of Water Analyses
Colloid Chemistry in Relation to Water Purification
Testing of Materials and Supplies

None of these reports is final but they are offered for the information of the members to show the present status of each respective subject according to the judgment of the committee members, and especially for the important purpose of facilitating discussion.

The Council has established the custom of requesting each committee to prepare a brief summary setting forth the status of the subject which they are handling. To promote ready discussion each chairman in reporting for his committee has been instructed to present a summary embodying the views of his committee and to move that the same be printed in the JOURNAL.

Progress reports have been received by Council from its other committees, some of which have information in shape for early use were it considered feasible or desirable by the Council to call upon them for discussion at this meeting. It is felt, however, that the program is amply filled and that it is more important to discuss the reports on the program rather than to present additional reports at this time.

The Council has established the custom of requiring quarterly reports of all its committees. The time has now been reached when it is essential for the Council to have progress reports reviewed in

[1] Presented before the Philadelphia Convention, May 17, 1922. Report adopted and the Council continued.

[2] See JOURNAL, September, 1921, page 535.

the JOURNAL after approval by it, so that they can be discussed at section meetings in various parts of the country. Criticism and exchange of views can thus be more satisfactorily handled than at annual meetings where only a limited discussion can be given reports, as compared with what would be procured at both annual and section meetings, particularly after there is opportunity for members to study the reports as published in tentative form.

The Council has encouraged committees to report their findings regardless of whether there is unanimity of opinion or not. Where different views have been encountered the committees have been asked to record such facts on the basis that such record would promote discussion and add value to the report rather than by attempting to eliminate or delay matters until differences of opinion disappeared.

In connection with this policy it should be made plain that the Council believes in proceeding cautiously and in not adopting resolutions of approval, except in a tentative way, until a thorough exchange of views has been secured. This will take time but it is believed that it will result in enhancing the value of the committee reports and the standing of the JOURNAL, as well as the prestige of the Association.

To carry out this program of prompt and full discussion of reports between annual meetings it will be necessary for the Publication Committee to devote considerable space in the JOURNAL to Council matters. While this may add somewhat to the expense of publication, the Council feels assured, from the contact which it has had with various members of the Association and other water works men not now members of the Association, that it will be to the lasting advantage of the Association to proceed along these lines.

The Committee on Abstracts, consisting of Messers. A. L. Fales, J. N. Chester, F. C. Jordan, R. S. Weston and Abel Wolman, has completed its work of organizing a department of abstracts for the JOURNAL. In the JOURNAL for September, 1921, page 537, this Committee reported the program it had undertaken. Upon the recommendation of the Committee on Abstracts and with the approval of the Council it was decided to appoint Mr. Frank Hannan of Toronto as Abstractor in Chief. Mr. Hannan accepted this appointment on February 9, and with the aid of the Committee on Abstracts has effected a permanent corps of about 20 abstractors. Coöperation has also been effected with other organizations doing similar work, particularly "Chemical Abstracts," the editor of

which has kindly consented to the use in our JOURNAL of such abstracts as desired, provided credit is given to the source of the abstracts as used.

Arrangements have also been made for securing abstracts of interest to members of the Association as given in the Bulletins of the U. S. Public Health Service, Department of Public Health Engineering.

The Council considers that this branch of the work is now well under way under the guidance of Mr. Hannan and with the aid of those abstractors whose names will appear after the abstracts as printed in the JOURNAL. With this successful termination of its work the Council has accepted the final report of the Committee on Abstracts and looks forward to a growing record in the JOURNAL of useful information of this character.

During the past year the Council has spent $144.88 and it has requested that the Finance Committee include for the use of Council an item of $2000.00 in the budget for the next fiscal year.

Already the council has found occasion to deal with a number of other organizations in a coöperative way in the field of standards. These include the American Society of Testing Materials, the U. S. Bureau of Standards, the U. S. Geological Survey, the Engineering Standards Council, the American Public Health Association, and the New England Water Works Association.

It is the intention of Council to deal with various water works topics that are of interest in particular to the practical water works man. Work of the past year has dealt to a considerable extent with the quality of water. This is due mainly to the activities of committees and members engaged in such work, but it is the purpose hereafter of Council to have four or five committees prepare reports for each annual meeting, so arranged as to cover various branches of the water works field.

Later reports from each committee will be required in order to sum up the results of the discussions of its earlier reports. Detailed reports will not be required each year of all committees and the rate of progress will depend on actual happenings in each field and the discussion of them by the members of the Association.

Special attention at this Convention is required on the subject of Standard Methods of Water Analyses and Water Standards.

On May 15 the U. S. Public Health Service organized at Washington an Advisory Committee on Official Water Standards. Four sub-committees were appointed, namely, bacteriological; chemical

and physical; field survey; and standards' appraisal and application. Some forty individual workers attended this meeting and there were also present representatives from American Public Health Association, American Water Works Association, American Chemical Society, American Society of Bacteriologists, American Railway Association, American Medical Association, American Society of Civil Engineers, American Association for Municipal Improvements, Association of Official Agricultural Chemists, Conference of State and Provincial Health Authorities, Conference of State Sanitary Engineers and representatives from the following Government organizations: U. S. Geological Survey, Bureau of Chemistry, War Department, Navy Department, Bureau of Standards, Bureau of Fisheries, and U. S. Public Health Service.

As the scope of this work relates to activities which have been under consideration by the committees of this Association and in which movement many of its members are vitally interested, the members of the American Water Works Association present at Washington announced the keen interest of this Association in the undertaking and pledged the support of our Association to it.

This important movement should stimulate several of the Committees now at work under the Council to activities on perhaps a somewhat broader scale than hitherto, and details of a program of procedure to this end should be decided upon at this Convention.

Coöperative work on this nation-wide movement means not only activity on the part of those who work in these special fields but it also means that careful preparation should be made for presenting the results of such efforts in an efficient way to the central organization at Washington.

In view of the number of recent discussions as to relative merits of steel pipe as compared with other materials for certain types of pipe lines, the Council has decided to appoint a committee to consider the subject of steel pipe lines. The personnel consists of the following: Messrs. Theodore A. Leisen, chairman; Allen W. Cuddeback; G. G. Dixon; J. W. Ledoux; Leonard Metcalf; Charles T. Bragg; and H. Seaver Jones.

GEO. W. FULLER, *Chairman*,
GEO. A. JOHNSON
FRANK A. BARBOUR
EDWARD BARTOW
GEO. C. WHIPPLE
Council on Standardization.

REPORT OF COMMITTEE ON STEPS TOWARD STANDARDIZING STATED QUANTITIES FOR SLIDES IN METER SCHEDULES[1]

Your Committee presents the following preliminary report, with the request that it be made the subject of general discussion, which will facilitate the preparation of a final report.

The subject assigned to the Committee is somewhat limited in scope, covering only the question of the standardization of quantities in the steps of the schedule. This matter is so closely related to other phases of meter rates that your Committee has found it desirable to touch upon certain questions outside of the stated subject. It recommends that, in its further work, it be empowered to cover the whole field of meter rates.

Many rate schedules in use by water works today have been handed down from early days. In many cases they do not provide a reasonable distribution of the burden of the charges. Each consumer of a water utility should unquestionably pay his proportionate share of the expenses of operation, depreciation and a fair return on the valuation of the property. It is distinctly unfair for one consumer or class of consumers to pay any of the costs of any other consumer or class of consumers. The burden should be equitably distributed. Rates should be just and reasonable both for the consumer and the utility. It is the opinion of the Committee that the scientific readjustment of rate schedules to a reasonable and equitable basis is one of the most important questions confronting water works utilities today.

It is believed that the results can be most expeditiously accomplished through the recommendations by this Association of a standard method of procedure.

Existing meter rate schedules embrace a great diversity of forms. They include uniform rates, sliding scales, jump scales, service charges, minimum charges, meter rentals and modifications and combinations of the above. Sliding scales vary from two or three

[1] Presented before the Philadelphia Convention, May 19, 1922. Report to the Council on Standardization.

steps up to a dozen or more. In some cases the spread or ratio between the highest and the lowest rates is ten to one or more. A majority of schedules retain the minimum principle, allowing the consumer a stated amount of water for a minimum charge. In some plants the water allowances under the minimum charge are so liberal that most of the accounts come under the minimum. This condition offsets to a large extent the advantages of the meter system. Because of the irregularity in minimum practices, and the great variety and number of steps in the scale, existing rate schedules do not lend themselves to ready comparison.

About sixteen years ago, a Committee of the New England Water Works Association, of which the late Freeman C. Coffin was Chairman, presented an excellent report on the subject of meter rates.[2] The method recommended consisted of a uniform meter rate for all quantities of water used, with a rather large service charge, the amount of which was dependent upon the frontage of the property. The service charge was to be collected in all cases whether water was drawn through the meter or not, thus providing an assured income for the utility, and making possible lower rates for water than would otherwise be necessary. The excellence of the recommendations of the Coffin report was generally recognized. Some of the principles set forth have been applied in rate schedules, but the method as a whole has not been adopted.

Following the Coffin report, a second Committee on Meter Rates was appointed by the New England Water Works Association, about nine years ago, to make a thorough study of the whole field of meter rates. The work of this Committee, involving the collection of meter rates and statistics of the water works of many cities, covered a period of about three years. A preliminary report[3] by the Committee was presented in September, 1914. At a meeting of the Association in March 1915, the scope of the Committee's work was extended to include an investigation upon the water unaccounted for or lost in leakage, as this question is involved in meter rates. This matter was made the subject of an additional report by the Committee, in which was included also suggestions for service charges for large meters.[4] The final report[5] was presented

[2] Journal New England Water Works Association vol. 19, 1905, p. 322.
[3] Journal New England Water Works Association vol. 28, 1914, p. 199.
[4] Journal New England Water Works Association, vol. 30, 1916, p. 453.
[5] Journal New England Water Works Association vol, 30, 1916, p. 361.

in February, 1916, and after much further discussion was adopted by the Association in November, 1916. It has been the standard of that Association to the present time.

The standard form of meter rate schedule recommended by the Committee and adopted as a standard by the New England Water Works Association contains three steps or slides. The first step, called for convenience, the Domestic Rate, includes all water up to 300,000 gallons per annum (820 gallons per day.) The quantities of water included in this rate will include substantially all water used by private residences, excepting a very few houses having large grounds.

The second or Intermediate Rate applies to quantities in excess of 300,000 gallons per annum up to 3,000,000 gallons per annum.

The third and lowest rate is called the Manufacturing or Wholesale Rate and applies to quantities in excess of 3,000,000 gallons per annum.

It was recommended that the price per 1000 gallons, or per 100 cubic feet, be an even number of cents, eliminating fractions, for convenience in billing and accounting. It was further recommended that the Intermediate price for water be to the nearest cent midway between the average and the mean proportional of the Domestic Rate and the Manufacturing Rate. By this rule the Intermediate Rate is definitely fixed at an amount midway or a little below midway between the Domestic and Manufacturing Rates.

The schedule does not fix the rates to be charged. These are to be fixed for each case as may be necessary to produce the required revenue.

The following are the forms for the schedules. They are given in alternate forms, according to whether gallons or cubic feet are used, and whether the unit of time is quarterly or monthly.

Quantities in gallons, bills quarterly

For each service supplied by $\frac{5}{8}$ inch meter there shall be a charge for the service and meter per quarter of	\$........
In addition thereto, for all water drawn there shall be charged:	
	Per 1000 Gallons
For the first 75,000 gallons of water per quarter, or any part thereof, the *Domestic Rate* of	\$........
For water in excess of 75,000 gallons and under 750,000 gallons per quarter, the *Intermediate Rate* of	\$........
For water in excess of 750,000 gallons per quarter, the *Manufacturing Rate* of	\$........

Quantities in gallons, bills monthly

For each service supplied by $\frac{5}{8}$ inch meter there shall be a charge for the service and meter per month, of..... $........

In addition thereto, for all water drawn there shall be charged:

Per 1000 Gallons

For the first 25,000 gallons of water per month or any part thereof, the *Domestic Rate* of........................ $........

For water in excess of 25,000 gallons and under 250,000 gallons per month, the *Intermediate Rate* of............ $........

For water in excess of 250,000 gallons per month, the *Manufacturing Rate* of............................. $........

Quantities in cubic feet, bills quarterly

For each service supplied by $\frac{5}{8}$ inch meter there shall be a charge for the service and meter per quarter of..... $........

In addition thereto, for all water drawn there shall be charged:

Per 100 cubic feet

For the first 10,000 cubic feet of water per quarter or any part thereof, the *Domestic Rate* of................. $........

For water in excess of 10,000 cubic feet and under 100,000 cubic feet per quarter, the *Intermediate Rate* of....... $........

For water in excess of 100,000 cubic feet per quarter, the *Manufacturing Rate* of............................ $........

Quantities in cubic feet, bills monthly

For each service supplied by $\frac{5}{8}$ inch meter there shall be a charge for the service and meter per month, of..... $........

In addition thereto, for all water drawn there shall be charged:

Per 100 cubic feet

For the first 3,300 cubic feet of water per month, or any part thereof, the *Domestic Rate* of................. $........

For water in excess of 3,300 cubic feet and under 33,300 cubic feet per month, the *Intermediate Rate* of........ $........

For water in excess of 33,300 cubic feet per month, the *Manufacturing rate* of.............................. $........

For the information of the members of the Association, and to facilitate discussion, the following table is given, showing the quantities probably included under the various classes in an average system, based on a summary of the investigations of the New England Committee covering some 35 water works.

	Domestic	Intermediate	Wholesale or Manufacturing
Percentage of whole number of takers	95.17	4.37	0.46
Average sales per service-gallons per day	159.0	1750	35,700
Percentage of metered output in the three classes	38.2	19.7	42.1
Percentage of water classified for payment	48.4	19.2	32.4

The population served with water by meter rates under the New England Water Works Association form of schedule is very large. The following places may be noted:

Spring Valley Water Company—3 rates		
San Francisco	506,676	
San Mateo County (in great part)	36,781	543,457
East Bay Water Company—2 rates (Domestic and Intermediate) the same		
Alameda	28,806	
Albany	2,462	
Berkeley	56,036	
Oakland	216,261	
Piedmont	4,282	
San Leandro	5,703	
Richmond	16,843	
And others		350,000
Hackensack Water Company—4 rates		355,000
Consolidated Water Company of Suburban New York—3 rates		15,000
Greenfield, Mass.—3 rates		15,462
Norwich, New York—3 rates		8,268*
Sault St. Marie, Mich.		12,096
Goldsboro, N. C.—3 rates		11,300
Springfield Consolidated Water Company of Philadelphia, Penna.—3 rates		165,000*
Commonwealth Water Company, New Jersey—4 rates		62,000
East Jersey Water Company, New Jersey (Applied for)—4 rates		441,380
Total population		1,992,600

*Form of rate based on, but not identical with standard

Your Committee has obtained the views of each member of the former Committee on Meter Rates of the New England Association as to the desirability of making any changes in their recommendations. No important changes have been suggested. It would

appear that individually the members of the New England Committee after a lapse of six years, still hold to their former findings.

Your Committee has also written to representatives of the works that have adopted the New England schedule without modifications or with relatively unimportant modifications, in order to obtain the benefit of their views based upon practical experiences with this form of rate schedule. Replies from these representatives have expressed general satisfaction with the schedules, both from the standpoint of the utility and of the consumer. No radical departures from the standard form were suggested. Two of the replies, however, indicated a desire to incorporate in the schedule a fourth and lower rate for large manufacturers.

Expressions of opinion of members of the old New England Committee, and of the representatives of the plants operating under the New England standard form of rates, have indicated the desirability of having a standard form which would be uniform for both Associations. Your Committee is also unanimously of the opinion that there should be complete uniformity in the recommendations of the two Associations. One of the most important objects to be gained from the adoption of a standard form of rate schedule is the simple fact that it is a standard, in a form recommended by the leading water works associations, approved by the various public utility commissions, and must ultimately be received and recognized as an established procedure by the consumers. Conflicting recommendations by the two largest Associations would largely defeat the purpose in view, and to this end, the work of your Committee was placed before the New England Water Works Association, at the recent Convention at Bridgeport, Conn., with the result that their co-operation was obtained, and Mr. A. E. Blackmer was appointed as a representative of the New England Water Works Association to co-operate with your Committee.

From the evidence at hand relative to the practical and satisfactory operation of the New England standard form of rates in the plants above mentioned, and owing to the desirability of the adoption of a standard which both Associations could accept, and to the fact that the New England form of rates has been successfully adopted and is used by a number of large water works systems, your Committee has seen no good reason for departing in any great measure from the recommendations of the former New England Committee.

The steps designated are as suitable for the purpose as any that your Committee can now propose.

Your Committee now presents this schedule to this Association for discussion, with a view to its ultimate adoption by the Association if such action appears desirable.

If, on the other hand, the discussion should indicate advantageous changes that your Committee can accept, it will be our idea to coöperate with the New England Water Works Association, through its delegate appointed for that purpose, to see if the matters cannot be adjusted, and the schedules put in such shape that they will be satisfactory to, and can be adopted in identical form by, both Associations. If this could be done, it would establish a standard which water works operators might approach, as far as conditions permit, whenever rates are being revised and that may be adopted in whole or in part as found feasible.

The final report of the New England Committee, as adopted by that Association, provides only three slides in the rate schedule. In the preliminary report of the New England Committee, it was tentatively suggested that if it was thought necessary to make a fourth and lower rate, that this be called a *Special Rate* and that it be made to apply only to quantities in excess of 30 million gallons per annum. Your Committee is of the opinion that, under certain local conditions, in plants supplying large industries, a fourth special rate of this character is desirable, in order to encourage the liberal use of water for manufacturing purposes and to attract new enterprises. It suggests, therefore, that the fourth or special rate be incorporated in our schedule, to be used only rarely, where local conditions demand it, and that it apply only to quantities in excess of 30,000,000 gallons annually, as recommended in the New England Committee's preliminary report. It may be mentioned that the Hackensack Water Company, in adopting this form of schedule, actually established such a special rate for quantities in excess of 30,000,000 gallons per annum, and the East Jersey Water Company has now pending an application for a similar rate.

While your Committee makes no further suggestions for any changes in quantities in the schedule adopted by the New England Water Works Association, it submits the following as an improvement in form, inasmuch as it shows the exact amount of water delivered at the specified rate without the necessity of subtraction. This arrangement, moreover, is more generally approved by the Utility Commissions. The monthly-gallons-basis is selected as an illustration. Other methods of billing would be in similar form.

General use charges—Monthly basis

Service charges

Size of Meter	*Monthly charge*	*Size of Meter*	*Monthly charge*
$\frac{5}{8}$ inch or less	\$........	3 inch	\$........
$\frac{3}{4}$ inch	....	4 inch	....
1 inch	....	6 inch	....
$1\frac{1}{2}$ inch	....	8 inch	....
2 inch	....		

For water delivered. In addition to the service charge, there shall be a charge for all water delivered, as follows:

For the first 25,000 gallons per month....\$........ per 1000 gallons
For the next 225,000 gallons per month.....\$........ per 1000 gallons
For all over 250,000 gallons per month.....\$........ per 1000 gallons

Where the fourth or special rate is used, the schedule will be as follows:

For the first 25,000 gallons per month......\$........ per 1000 gallons
For the next 225,000 gallons per month.....\$........ per 1000 gallons
For the next 2,250,000 gallons per month...\$........ per 1000 gallons
For all over 2,500,000 gallons per month....\$........ per 1000 gallons

Where multiple meters are used the service charge for each should be applied. Where several meters are used on one service, because of greater convenience and accuracy in measurement, the quantities shown by the several meters are to be combined before billing, giving the taker the advantage in classification resulting therefrom. But where several meters of one taker deliver into separate pipe systems serving different purposes and maintained for the convenience of the taker, each is to be treated as a separate service. The Committee calls attention to the fact that this is in general agreement with the procedure recommended by the Committee on Private Fire Protection presented June 10, 1919, and found in the JOURNAL for November 1919, page 736.

SLIDING SCALE

A rate schedule in the above form is called a sliding scale. Many works now make a single rate for water, applying to both large and small consumers. This is called the uniform rate. This is a much discussed question, and some water works men are of the opinion that a uniform rate should prevail for all classes of consumers, basing their opinion largely on the so called doctrine of equal rights to all, and special privilege to none. It must be admitted, however, that it costs more per 1000 gallons to serve a small than a large consumer. Referring to the summary of statistics, prepared by the New England

Water Works Association Committee, based on the averages of 35 plants, it will be noted that the average amount sold per service per day to domestic consumers is 159 gallons, to manufacturing takers, 35,700 gallons; corresponding to 4770 and 1,071,000 gallons per month respectively. From these statistics it appears that, on an average, one industrial consumer uses as much water as 225 small consumers. It is obvious that the expenses of operation incidental to the reading of meters, delivering bills, office accounting, and the maintenance of 225 services, are vastly greater than for the single large consumer.

There is another charge that might theoretically be added to the service charge, but which practically is not and cannot well be. That is the cost of the 6 inch and 8 inch pipe necessary to carry the water to these smaller services. In an average water works system, the 225 small takers, mentioned above, will require, let us say, two miles of 6-inch and 8-inch pipe for their convenience. The one large taker will probably be on or near one of the main feeders, and will require no service corresponding to that represented by the two miles of the 6- and 8-inch pipe, or at most only a small fraction of it. The cost of this 6-inch and 8-inch pipe is a substantial percentage of the whole cost of an average system. To distribute this cost fairly, the large takers should be asked to pay only a small fraction thereof, while the small takers should carry most of it. Under the Coffin System, mentioned above, this charge would all go in the service charge in proportion to frontage. This is theoretically right, but actually is not practicable. The common method is to use the sliding scale, by means of which this part of the cost is put as a loading on the first water drawn from each service; so that it is carried, not, as in the Coffin report, in proportion to the frontage, but rather in proportion to the size of the houses and the amounts of water drawn and the ability of the takers to pay. It is a good practical working system and its feasibility is fully demonstrated by abundant practice.

There are other points to be considered. There are frequently limits to the amounts that can be collected for water for manufacturing purposes. If the rate is too high the business is not there. It is not necessary to go into this here, but it frequently happens that surplus capacity provided to cover expected growth may be turned to advantage in the interval before it is needed, by being sold for manufacturing purposes at rates, that, while much lower

than domestic rates, still help to carry the system through what would otherwise be a trying period. Often business of this kind actually makes possible lower domestic rates. There has been much discussion and experience along these lines.

The practice of American communities justifies the belief that there is room for and need of the sliding scale. The principal need of the sliding scale is to cover the extra cost of distribution to small takers.

Where the costs of the water pipes when laid are assessed against the takers, as is the case in a small number of American cities the reason for the sliding scale is in great part removed.

Nothing in this Committee's report should be taken as excluding the uniform rate with proper service charges, where local conditions are favorable. It is only a special case coming under the proposed general form. The slide may be more or less as conditions require. When the slide is made zero the rate becomes uniform.

Most of the criticism against the sliding scale has been because of excessive slides, in which a large user obtains water for $\frac{1}{8}$ or $\frac{1}{10}$ of the price per 1000 gallons that is paid by the small user. No defense can be made of such schedules, as they are obviously discriminatory in favor of the large user. Your Committee does not recommend a definite limit as to amount of slide, except to follow, in a general way, the informal recommendation of the New England Water Works Association Committee that the ratio between the domestic and manufacturing rate should rarely exceed 2 to 1. For purposes of discussion, your Committee might further tentatively suggest that in cases where the fourth or special division is used, for very large takers, the amount of slide should not exceed the ratio of 3 to 1.

SERVICE CHARGE.

The classification of quantities now presented is based upon the use of a service charge. Your Committee is of the opinion that it is essential to make a substantial service charge in order to secure equitable rates for all. Departures from long established procedure are invariably met with opposition. Most of the opposition to the service charge, it is believed, has been due to an improper understanding of the principles involved. It has largely grown out of the erroneous idea that the service charge is an additional charge and means higher rates. As a matter of fact it is simply a different

way of distributing the burden and of changing it to correspond more nearly with the actual costs of service.

An examination of the expenses of any water company will show a large number of expenditures in no way related to the amount of water sold. These expenditures would continue even though no water were sold. It is evident, therefore, that a commodity rate cannot properly distribute the costs of service and that the only means to spread the burden equitably is through a service charge.

MINIMUM CHARGE

A Minimum Charge fixes the least amount to be collected from any consumer, but allows him up to a stated amount of water for the stated charge. The amount of water allowed is usually fixed by the amount which the consumer could buy under the highest rate. For instance, with a minimum rate of $1.00 per month, and the highest rate 25 cents per 1000 gallons, the consumer is allowed up to 4000 gallons per month for the minimum charge. Under such a schedule, a consumer who used only 1000 gallons of water per month pays as much as one who uses the full allowance of 4000 gallons per month, which is obviously discriminatory. A properly determined service charge will always be less than a corresponding minimum rate for any connection. Under many rate schedules now in use, the minimum charges for the larger sizes of meters are wholly inadequate. The substitution of a proper service charge for such connections would necessitate a considerable increase in rates to those takers who have large services through which but little water is taken. Such takers may either substitute a smaller meter, suitable to the quantity of water actually taken, or, if they need the capacity of the larger service for fire service or other occasional use, they should pay a fair price for the service rendered,—and the service charge furnishes this basis.

RECENT RECOGNITION OF SERVICE CHARGE

The service charge principle is slowly but surely receiving general recognition. Rate schedules based upon service charges have been approved in recent rulings by the Public Service Commissions in New Jersey, Pennsylvania, Wisconsin and California, and perhaps other states. Public opposition to the service charge has been particularly observed in Pennsylvania, to the extent that a bill (making such a charge illegal) instituted by the Associated Boroughs,

was pending before the last session of the Legislature. It is to be noted, however, that on the advice of counsel for the Boroughs, the bill was withdrawn.

The New York Commission has ruled—"A service charge is a legal and just charge if properly adjusted as to the amount." In a recent decision in a gas case, this Commission condemned the minimum principle, as follows (this finding applies equally well to water):

The *Minimum gas rate is inequitable.* A sample case cited is the best proof. Mr. A. and Mr. B. are in the minimum class, which is placed, say, at $1.00. Mr. A. used 90 cents worth of gas a month; he pays $1.00. Mr. B. used 20 cents worth of gas a month; he pays $1.00. If the interest on the service investment to that residence or office is 50 cents, the company sustains a loss from Mr. A. of 40 cents that must be made up by some other consumer, while it has made a profit of 30 cents off Mr. B.

In an order by the Railroad Commission of California, in the case of the Spring Valley Water Company, September 3, 1918, the following was stated:

We have given this matter very extensive and careful consideration and have arrived at the conclusion that the sound basis for establishing these rates is that there should be first a service charge based on the size of meter, which service charge is to be paid by all consumers—regardless of the amount of water used.

This in distinction to the establishment of a minimum charge which involves the payment of a fixed sum by each consumer based on the size of the meter used and which sum includes a service charge together with a charge for a given quantity of water whether used or not. The minimum charge is invariably higher than the service charge, and it involves the payment by each consumer for a fixed amount of water regardless of whether or not he used it. There is no answer known to us which can be made to the man who complains that under a minimum rate he is compelled to pay the same amount for one hundred cubic feet of water as his neighbor pays for three or four hundred cubic feet of water, depending on the amount fixed for minimum use.

On the other hand the establishment of a service charge is designed to exact from each consumer the cost to the company of standing ready to serve and thereafter to pay for only such water as he may use.

We believe that under the conditions of service we are dealing with herein, the service charge once established and thoroughly understood will be agreed to as the fairest and most equitable method of fixing rates.

After fixing the service charge we have given consideration to the charge per hundred cubic feet for water used, and in this connection we have recognized the so-called wholesale principle.

Throughout California flat rates for water service have come to be recognized as unfair and inequitable as between consumers. These rates encourage the wasteful and selfish user to impose an unfair burden upon the thrifty and considerate.

The equity and fairness of rates by measurement cannot be successfully challenged.

With these considerations in mind we have adopted the meter rates set out in the order.

It is of interest to note that the rate schedule adopted in this case is in exact accordance with the standard form recommended by the New England Water Works Associatoin.

The above and many other incidents indicate the increasing recognition of the service charge as the most logical and rational method yet proposed for a suitable rate structure.

DETERMINATION OF RATES

The problems involved in the determination of a fair and equitable rate necessitate the proper and rational division of costs for each different class of service. The theoretical allocation of these costs results in the "three part" rate of (1) Consumer or Service Charge, (2) Demand Charge, (3) Commodity Charge.

The Consumer Charge covers the cost of meter reading, billing, collecting, accounting, repairs and maintenance of meters and services, etc., covering all costs relating to consumers and having no bearing on the quantity of water used by consumers or the maximum demands.

The Demand Charge covers the final costs of the system as maintained to serve the peak load demands upon the plant. This expense is not dependent upon the amount of water consumed. The theoretical charge under this heading for each consumer should obviously be an amount equivalent to his actual maximum demands. It is impractical to ascertain this, however, in the absence of maximum rate recording meters, and the usual method of apportioning this charge to the consumer is on the basis of the unit capacity of the meters.

The Commodity Charge is the charge for the water itself. It covers all costs having to do with the production of the water, and such delivery costs that are proportionate to the amount of water sold.

It is believed there will be unanimity of opinion amongst water works engineers as to the division of the costs of water plant operations into the general classes above. This division of costs has also been recommended for the gas industry, in the 1921 Report of the Rate Structure Committee of the American Gas Association.

The three part rate, as applied to the gas industry, is also discussed in an article by Page Golsan, of the staff of Ford, Bacon and

Davis, in a recent issue of *Gas-Age Record*. This article has been reprinted in pamphlet form, under the title of "Service Charge for Gas Companies." It contains a strong plea for the adoption of a service charge by the gas industry.

There is a divergence of opinion relative to the apportionment of the expenses of plant operation under the respective headings of the three part rate, and their equitable distribution in the rate schedule after they have been determined. To be applied in the rate schedule the three divisions of cost, excluding charges for fire protection, must be properly apportioned to the fixed service charge and the commodity charge or rate per 1000 gallons. It is generally taken that the service charge as levied in the rate schedule should be the sum of the consumer and demand charges, leaving the commodity charge to be applied to the water used. The strict application of theory, however, must be tempered with judgment. If the inclusion of all demand charges resulted in unduly high service charges, it would undoubtedly be desirable to modify the method. All writers on this subject do not concur in the proposition to include all of the demand charges in the service charge. In the article by Page Golsan, referred to above, he states:

> In the form of rate usually adopted the Service Charge covers the customer charge, together with that portion of the demand charge found in the *fixed costs of the meter and service pipe*; while the rate per 1000 cu. ft. includes the commodity charge for gas, and being of a declining block character, absorbs the balance of the demand charge. The sum of the consumer charge, together with this definite portion of the demand charge directly assignable to each customer, comprises the usually defined Service Charge. The Service Charge in the gas business is just now coming into general usage. Its exact definition is, therefore, yet to be laid down. Many views exist as to the items to be included, varying from the mere customer charge to a large portion of a full demand charge. . . . No doubt exists, however, concerning (1) the customer charge, (2) the fixed charges on the meter and part of the service, and (3) the fact that there are certain other additional fixed charges. The usually adopted Service Charge recognizes the possible variation in factor (3) in being set at a lesser amount than the allocated costs of a typical installation.

The recommendations of the New England Committee include a suggestion for procedure in the method of determining the service charge, based on

(1) Annual interest and depreciation on the average investment made by the works in the service pipe and meter.

(2) The sum per annum representing approximately the cost of reading meters, keeping meter records, making bills and collecting the money.

(3) An amount covering the approximate average value to the works of the water that passes through the meter without being registered.

The above method would limit the service charge to costs related only to the consumer's meter, necessitating the absorption of general plant demand costs in the commodity charges. This procedure closely agrees with the method described above, as quoted from the paper on "Service Charges for Gas Companies."

In discussion of the final report of the New England Committee on Meter Rates, the following suggestion was made for the division of the whole cost of supplying water.

(1) The cost of supplying water up to the point where water is delivered under pressure up to a reasonably central point.

(2) The cost of distribution.

(3) The service cost, including costs of service pipes and meters.

In view of the divergence of opinion on the questions of the establishment of a proper rate structure, it is obvious that no definite recommendations can be made without further study of the conditions involved and careful deliberation. Your Committee, furthermore, has considered this to be beyond the scope of its present instructions, but, owing to the importance of a general revision of rates, it recommends that its scope be extended to cover the entire subject of the form of rate schedule.

The Committee does not intend any recommendations contained in the above report to be considered as final. Its idea has been to review briefly the important points relative to rate matters and to present a basis for discussion by members, prior to final consideration and report.

Respectfully submitted,

Allen Hazen, *Chairman*,
Isaac S. Walker, *Secretary*,
Theodore A. Leisen,
George N. Schoonmaker,
Burton Lowther,
Committee.

Arthur E. Blackmer,
Representative of the New England Water Works Association.

Florence M. Griswold

Died April 25, 1922

Florence M. Griswold was born in Hoboken, New Jersey, in November, 1843. He received his education in the public schools and at Wittenburg College, Springfield, Ohio. During the Civil War he served with the Union forces. At the close of the Civil War he returned to Cincinnati and became special agent of the old North American Fire Insurance Company of New York, and under the supervision of his father, Jeremiah Griswold, general agent of the company, spent several months in general field work in that territory. In 1866, he was appointed assistant general agent of the company and served in that capacity until 1870. In the succeeding five years he was connected in various responsible capacities with several of the principal fire insurance companies, becoming in 1875 the general inspector of The Home of New York with headquarters in New York City. Since that time he has had charge of the special hazards and technical work conducted by The Home Insurance Company throughout the whole field of its operations.

At the time of his entry into the fire insurance business, this enterprise was admitted to be a "system of magnificent guessing" as to hazards and rates, wherein a risk was assumed almost without regard to physical or other hazards. A short experience convinced Mr. Griswold that such a method was entirely empirical and he began to study the needs of the situation, in order to develop the scientific principles underlying it and to put into operation any conclusions derived. Among the most important of these was the realization that the obligations existing between the insurer and the insured are properly mutual, and that anything which tends to the profit or safety of one is of value to the other.

Building upon this foundation, he made himself familiar with the processes and methods of all clases of manufacturing industries and the fire hazards incident to each, and then began the work of making better that which came under his supervision. He

assisted in the organization of many of the inspection bureaus and he had an active hand in the formulation of a number of schedules for rating industrial plants. From the length of his service and the knowledge gained by his unceasing study and investigation of fire hazards, he became perhaps one of the best versed men in his profession and was frequently referred to as "The Dean of Fire Insurance Engineers."

In addition to his work in prevention, he devoted much attention to the betterment of public and private fire protection. In this particular field, Mr. Griswold was brought into intimate contact with the fire and water departments of many of the principal cities of this country. For many years he was an ardent advocate and a strenuous worker in the attempt to secure universal standards for all classes of fire fighting facilities and utilities, especially for public fire hose connections. The need for standard hose and hydrant threads was apparent. In view of the broad experience and wide acquaintance he had throughout the country, the National Fire Protection Association selected him to head a special committee to secure the adoption of a universal standard. Mr. Griswold accepted the task with full knowledge of the many attempts and failures of past efforts for its accomplishment. As the result of this persistent effort he secured the official endorsement of his coupling by all of the leading and most influential organizations of the country, thus establishing a standard coupling. In 1917, this coupling was approved and adopted by the United States Bureau of Standards as the "National Standard Hose Coupling and Hydrant Fitting" for public fire service.

Mr. Griswold was a member of the Grand Army of the Republic, the American and the New England Waterworks Associations, the American Society of Mechanical Engineers, and associate member of the International Association of Fire Engineers, to which organization he has for many years been the accredited delegate from the National Fire Protection Association; and honorary foreign correspondent of the British Fire Prevention Committee, and an Honorary Life Member of the National Fire Protection Association.

He was active in his work and was in close touch with all technical matters affecting fire prevention work. Few men have had so important a part in bringing fire underwriting to a point where it can in some truth be called an applied science.

During his business connection, embracing forty-seven years in the study of the technical principles of fire underwriting, many authoritative publications on fire prevention were prepared for The Home Insurance Company, whose interest he held paramount to all others.

We can testify to his strict integrity and loyalty. We regret, with all others who had the pleasure of his acquaintance, that so much has been lost to the fire insurance business.

DISCUSSIONS

THE VALUE OF METER TESTING BEFORE INSTALLATION

Two years ago it became necessary in this City, owing to the policy of metering each service which had been determined upon by the City Council, to devise ways and means for the testing of the measuring apparatus.

A standard meter testing outfit had been purchased by the writer's predecessor, but had never been used. While aware of the fact that meter companies do test each meter before it leaves the factory, it was thought expedient to perform our own tests. Our experience during the past eighteen months would justify the conclusion that the decision was correct. The expense involved in making tests is not a great one, and may be negligible, in our particular case, the work being performed by operators at the filter plant, who also attend to all meter repairs.

Our requirements for registration and capacity are virtually those specified in the Standard Specifications[1] for water meters recently adopted by this Association. Unfortunately the first lot of meters purchased gave us considerable trouble and annoyance due to lack of accuracy of registration within permissible limits on the fine stream, the proportion of rejects for this reason being 20 per cent. These meters had been stored in our shop six months and the manufacturer claimed that this feature coupled with an unsatisfactory water which they used for testing purposes was responsible for the lack of sensitiveness. At any rate, steps were immediately taken for making adjustments necessary, in which they were successful in large measure, only 15 per cent of the rejected batch being returned to the factory for replacement.

Later requirements of meters were purchased on rigid specifications, the percentage of rejects being negligible although apparently inexcusable defects such as sand holes, disk chamber slightly open, etc., were passed.

In view of the foregoing, we think it proper, and the expense justifiable, that each meter be tested for accuracy of registration before its installation. RICHARD F. WAGNER.[2]

[1] See JOURNAL, May, 1921, page 273.

[2] Superintendent and Engineer, Department of Water, Lynchburg, Va.

THE LOADING OF FILTER PLANTS[3]

Mr. Streeter's excellent paper on the loading of filter plants treats an important subject in a scientific manner. His scientific treatment is particularly gratifying, as in problems relating to filtration each phenomenon results from several causative factors, and it is very easy to draw erroneous conclusions as to cause and effect unless the statistical method is rigidly followed. There have been a number of instances in the recent past where this has not been done, and as a result false ideas have become current. It cannot be overemphasized that in these problems, which do not have the definiteness of typical problems in engineering or chemistry, the utmost caution must be used to avoid bias, and to this end the method of scientific statistics is an indispensable means.

If any comment may be made on the method of attack, it would be that the grouping adopted in table 1 is too broad. A more accurate, but more laborious way would have been to plot a point for each corresponding two values of raw and filtered water, and then determine the curve of best fit by the method of correlation.[4] A plot of all these points with such a curve or curves drawn through them would itself be of great interest. By proceeding in this manner it would also be possible to determine the coefficient of correlation, which would tell whether the correlation of the data were close enough to justify the formulation of a definite curve, or whether it were influenced by factors of which no account was taken. The same applies to table 4, the data of which might yield more definite results if treated as a problem in partial correlation. Such treatment would also give a means for estimating the accuracy of the results, as the probable errors could be found.

The question of Bact. coli results deserves special comment, particularly in view of the present practice of restricting the permissible Bact. coli in filtered supplies to very narrow limits. The relation between per cent positive tests and the number of bacteria causing same is not a simple arithmetic one. The writer has developed this relationship and has shown definitely that it is: $Q = e^{-x}$, where Q is the percentage of negative tests, and x the number of bacteria causing same. There are no assumptions in this relationship. It is absolute and the only correct one. If, of each sample,

[3] JOURNAL, March, 1922, page 157.

[4] JOURNAL, September, 1918, page 272.

raw or filtered, a sufficient number of tubes are made to obtain directly a value of Q, then the number of Bact. coli can be computed from this formula. If the tests from which the per cent positive is derived extend over a period of time—week or month, the matter is complicated by the fact that the Bact. coli varied in some unknown manner during this time and the above formula cannot be applied directly. The writer has devised a method making use of the contrast between the 1 and 10 cc. tests which gives results of reasonable value in this case also. All this sounds rather complicated, but for working purposes has been incorporated by the writer into several diagrams which can be readily used by anyone without mathematical knowledge. Even with these aids to the correct interpretation of Bact. coli results, it must be remembered that these are on a much lower plane of accuracy than plate counts. A single plate gives a perfectly definite number of colonies which can be counted directly. Thirty plates give thirty perfectly definite numbers, which can be averaged to give a result of known accuracy. Thirty fermentation tubes give but one number—a percentage, subject to vagaries of interpretation which the above noted methods can only partially overcome. This then is the relative accuracy—thirty perfectly definite values vs. one partially definite value. This question needs careful consideration in connection with filter plant standards.

The fact that Mr. Streeter's results approximately confirm the permissible load factor of the International Joint Commission does not, to the writer, imply any extraordinary prescience on their part, nor is it of special significance. This load factor was formulated quite recently in point of relative time of filtration practice (1915, I believe) when many bacteriological data were available. Knowing that the Treasury standard of 2 Bact. coli per 100 cc. could be attained in the chlorinated effluent of filter plants, and that such plants could be operated with an overall efficiency of 99.6 per cent, simple multiplication gives a raw water load of 500 Bact. coli per 100 cc.

The writer's experience is that the reason that the bacterial efficiency increases with the raw water count is that the turbidity also increases, necessitating more coagulant, consequently better settling and filter efficiency. With clear but badly polluted waters it is very difficult to obtain satisfactory removal of bacteria even with large amounts of coagulants, and in such cases the usual permissible load does not apply.

In conclusion, it may be said that the solution of this important problem is in good hands. It is to be hoped that the United States Public Health Service will continue its investigations, carefully analyze the data obtained, and publish the data and conclusions so that they may be available for reference to all sanitary engineers.

MILTON F. STEIN.[5]

[5] Civil Engineer, Chicago, Ill.

SOCIETY AFFAIRS

ILLINOIS SECTION

The fourteenth annual meeting of the Illinois Section was held at the University of Illinois on March 29 and 30, 1922. Thirty-two active members and representatives of three associates of this section were present. The program was as follows:

Wednesday, March 29, 1922, Union Building 1:30 p.m.

Address of Welcome, by Eugene Davenport, vice-president, University of Illinois.

Report of the Secretary, by G. C. Habermeyer.

Report of the Treasurer, by H. E. Keeler.

"Notes on Hydraulics of Wells," by M. L. Enger.

"Ground Water History at Bloomington," by D. M. Maxwell.

"Rockford Water Works," by R. C. Wilson.

"Well Data and Water Works Pumping Equipment," by John Oliphant.

"Park Ridge Pumping Station," by W. T. McClenahan.

"Public Water Supplies in Illinois," by H. F. Ferguson.

6:30 p.m., Annual dinner Inman Hotel

"Some Phases of Stream Pollution,"[1] by J. K. Hoskins.

Thursday, March 30, 1922, 9:30 a.m. Union Building

"Special Features of Recent Filter Plants," by Paul Hansen.

"Water Purification Plant Operation and Analytical Control," by M. W. Cowles.

"Use of Illinois Waters in Locomotive Boilers," by C. W. Carrick.

"Some Data on pH and Residual Alum," by A. M. Buswell and G. P. Edwards.

"Local Pollution of a Water Supply," by F. C. Amsbary.

"Tastes and Odors," round table discussion led by H. M. Ely.

[1] See page 570 of this Journal.

"Iron Removal" round table discussion. A. M. Buswell; W. A. Hutchins; F. C. Amsbary; S. A. Greeley; G. C. Habermeyer.

1:30 p.m.

"Motor Driven Centrifugals with Gas Engine Standby," by W. B. Bushnell.

"Coördination of Water and Fire Departments,"[2] by Clarence Goldsmith.

"Water Waste,"[3] by A. E. Skinner.

"Collections," by E. McDonald.

Round table discussion, Office Records and Accounting.[4] C. M. Roos; W. E. Lautz.

The following officers were elected for the ensuing year: Chairman, Henry Ringness, Peoria, Ill.; vice-chairman, C. M. Roos, Cairo, Ill.; treasurer, H. E. Keeler, Chicago, Ill.; trustee (to serve three years) W. R. Gelston, Quincy, Ill.; trustee (to serve one year), W. E. Lautz, Pekin, Ill. G. C. Habermeyer was appointed secretary.

The secretary was instructed to write to Mr. Keeler, who was unable to attend the meeting on account of sickness and who had attended every other meeting of the section, to express the regrets of the section at his absence and the hope of his speedy recovery.

A resolution[5] on fire pressure practice was adopted.

The meeting was one of the most successful that has been held by the Illinois Section.

[2] See page 595 of this JOURNAL.
[3] See page 624 of this JOURNAL.
[4] See page 617 of this JOURNAL.
[5] See page 601 of this JOURNAL.

EMPLOYMENT SERVICE OF THE FEDERATED AMERICAN ENGINEERING SOCIETIES

The Federated American Engineering Societies, the offices of which are at 29 West 39th Street, maintains a free employment bureau connected with any industry or profession in the United States. This bureau is a nation-wide clearing house for the employment of technical men. The service rendered is as valuable to the employer as the employee. About thirty societies and associations throughout the United States are members of the Federated Societies.

The bureau has advised the Journal of the American Waterworks Association that members of the American Waterworks Association, who are officials of or connected with organizations in which a central personnel department is not maintained, are at this time given a cordial invitation to make free use of the bureau, by advising the various departments in their organizations of the existence and usefulness of the Federated American Engineering Societies Employment Service.

The bureau is in a position to furnish consulting engineers, engineers on appraisals and valuations, inspectors, tests, designs and estimates, and superintendents of construction and maintenance.

The administration of the bureau is in charge of Mr. W. V. Brown, Manager, Employment Service, Federated American Engineering Societies, 29 West 39th Street, New York City.

ABSTRACTS OF WATER WORKS LITERATURE

Frank Hannan

Key: American Journal of Public Health, **12:** 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the journal.

Streamflow Experiment at Wagon Wheel Gap, Colorado. Carlos G. Bates and Alfred J. Henry. Monthly Weather Review, Supplement, no. 17, 1922. In order to make a complete study of the effects of forest cover on streamflow and erosion, the Forest Service, United States Department of Agriculture, selected a site for experiment on the Rio Grande National Forest, near Wagon Wheel Gap, Colorado. The plan was to select two contiguous watersheds, similar in topography and forest cover; to observe carefully the meteorological conditions and the stream flow for a term of years, under similar conditions of forest cover; then, to denude one of the watersheds of its timber and to continue the measurements as before for an indefinite period, or until the effects of forest destruction had been determined. The watersheds selected are noted as *A* and *B*.

Both drainage basins are almost completely covered with a relatively thin mantle of soil and decomposed rock, with some clay and numerous flat fragments of the underlying augite-quartz latite. The forest cover consists of Douglas fir, bristlecone pine and aspen.

The mean 1-foot soil temperature of watershed *B* is 2° higher than in the case of watershed *A*, while the temperature of all the springs on *B* is 0.6° less than that of the springs on *A*, at midsummer. In winter the stream on *B* is warmer than the stream on *A*, all of which indicates that the water sources of *B* are deeper than those of *A*.

The average precipitation over a period of eight years is practically divided between rain and snow. The interception of snow by trees and vegetation is small as compared with rain, because the coniferous area only is effective in preventing the snow from reaching the soil. Although the average snowfall is equal to the rainfall a greater portion of it percolates into the deeper soil and is later effective in maintaining streamflow. Amounts of precipitation for the two watersheds for eight years are almost the same, but in individual years they show considerable variation. The amount of water discharged by stream *B* is, on the whole, about 2 per cent greater than that for stream A. Evaporation is probably less on *B*, either because of the cover conditions or because *B* has a deeper and better storage reservoir, or both.

In 1919, after eight years (1911–1919) of continuous experimenting and recording of the precipitation, temperatures, etc., the process of denuding watershed *B*, was started, the experimenting, measuring and recording being continued as before.

The report contains valuable discussions of the various elements entering into the calculations of the relation between run-off and rainfall on the streams.—*A. W. Blohm.*

An Ancient Aqueduct in Brazil. S. T. Henry. Successful Methods, **4:** 3, March 1922. Built about one hundred and fifty years ago, a 7-mile masonry aqueduct was in continuous service until recently, supplying water to Rio de Janeiro. Aqueduct shows wonderful construction skill. Troughs were hewn out of solid blocks of stone, lined with terra cotta tile set in mortar. Side walls and arched-top were constructed to protect the conduit and water. All this was done with slave labor, in a dense tropical jungle far removed from the civilization of the day and with the crudest of hand tools.—*A. W. Blohm.*

Water Intake Protected Against Severe Conditions. Eng. News-Record, **88:** 6, 235, February 9, 1922. An extreme water level variation of 71 feet in the Ohio River, combined with the exceptional accumulation of debris, has led to the introduction of special plant for screening the water and removing the debris at the intake well of the West End Power Station of the Union Gas and Electric Company at Cincinnati, Ohio. This plant includes the largest installation of traveling screens in the world, having 16 screens 91 feet high and also a novel swinging crane for cleaning the well. Particulars of the intake well and tunnel to supply water at the rate of 208,000 gallons per minute were given in Eng. News-Record, September 27, 1919, 593.—*E. E. Bankson.*

Synura and Other Organisms in Catskill Water Supply. Wm. W. Brush. Eng. News-Record, **88:** 7, 266, February 16, 1922. Experience with taste and odor producing organisms reviewed. The taste has usually been designated as resembling a ripe cucumber, although many have designated it as fishy. The article outlines the unusual and successful methods of applying copper sulphate and chlorine to destroy not only these organisms, but also the taste and odors resulting therefrom with conclusions as follows: (*a*) Continuous treatment of the flow in the aqueduct with copper sulphate will destroy the microscopic organisms, (*b*) The addition of chlorine after the copper sulphate will destroy the tastes of the synura oil when sufficient chlorine is added. (*c*) A combination of copper sulphate and chlorine treatment of water high in microscopic organisms appears to be a satisfactory method of elimination of organisms and taste.—*E. E. Bankson.*

Waterproofing a Leaky Reservoir at Nashville, Tennessee. Eng. News-Record, **88:** 8, 311, February 23, 1922. A lining composed of two layers of gunite with asphaltic burlap membrane between them is the means adopted for waterproofing the masonry walls of the leaky reservoir. The membrane was extended over the concrete floor and covered with 4 inches of poured concrete.—*E. E. Bankson.*

Steel Standpipe Cleaned and Reinforced by Cement Gun. Eng. News-Record, **88:** 8, 315, February 23, 1922. In the recent cleaning and repair of a high steel standpipe a cement gun was used both to sand blast the corroded metal and to coat it with a mortar lining. The standpipe was first cleaned inside and out by the cement gun used as a sand blast, angle clips were then welded to the steel plates and heavy reinforcing wire mesh used throughout. Gunite was then shot into place, forming a continuous sheet over the bottom and walls.—*E. E. Bankson.*

The British Water Supply Shortage and Emergency Treatment Measures. London Correspondence. Eng. News-Record, 88: 8, 332, February 23, 1922. British authorities have now become thoroughly alarmed at the shortage of water throughout the country and are taking steps to insure that all supplies are conserved. In many districts water rationing has been resorted to and in many villages water is being retailed at so much per pail. Several rivers have dried up altogether and many deep seated chalk springs have completely dried up.—*E. E. Bankson.*

The Advantage of Maintaining Accurate Accounts by Utilities Subject to Regulation. WALTER H. BOHLING. Bull. Missouri Association of Public Utilities, 8: 3, 7, February 15, 1922. That regulation may be more intelligently and efficiently administered the books of the individual utilities of Missouri are required to speak a common language reflecting like expenditures and income in like manner, under the uniform systems of accounts prescribed by the Public Service Commission. Intelligent regulation depends primarily upon the value of the property, the costs of rendering the service and the revenue derived therefrom.—*E. E. Bankson.*

What Constitutes a Reasonable Return. W. H. BOWLING. Bull. Missouri Association of Public Utilities, 8: 3, 16, February 15, 1922. The point at which confiscation begins, marks the border line in valuation and rate fixing for fixing public utilities, is discussed in this article under headings as follows: (1) Introductory, (2) General, (3) Cost of money, (*a*) Interest rate on utility securities, (*b*) Legal rate of interest, (*c*) Prevailing rate of interest, (4) Prevailing return on comparable enterprises, (5) fluctuations. Exhaustive citation of legal decisions bearing on this aspect of successful utility operation is given.—*E. E. Bankson.*

The Cross Hill Covered Reservoir. Water and Water Eng. (London), 23: 275, 401, November, 1921. The claim is made that this reservoir is of unique design and probably the most economical one ever constructed. The contract was let in 1913 for 79,000 pounds or about 2800 pounds per million gallons of storage as compared with an average cost of 5000 pounds for several small covered service reservoirs built for the London water supply. The reservoir is hexagonal in shape, each side of which has eight arches, with a span of 30 feet and a radius of 27 feet 6½ inches, and a span and radius of 17 feet 4½ inches at the angles. It covers 3.6 acres and has a capacity of 30,000,000 gals. The total depth is 32 feet of which 5 feet is below ground level. The roof consists of 217 concrete domes, each 30 feet in diam., supported on 432 pillars built of hexagonal concrete blocks. The latter are 18 inches deep and 3 feet across between parallel sides, and 16 are used for each column. The blocks were vibrated during the process of moulding in order to insure a satisfactory and uniform quality of concrete. Tests showed that the vibrating increased the crushing strength about 6 per cent. The article is well illustrated by photographs.—*Geo. C. Bunker.*

Notes on the Examination and Disinfection of Drinking Water. J. Morison. Indian Jour. Med. Research (Special Indian Science Congress Number, 1920). Tropical Diseases Bull., Sanitation Supplement, no. 3, 204, October, 1921. The bacteriological examinations in practice may be limited to the estimation of lactose fermenters and the total count on agar. The bacteriological standard for a water whose source is beyond suspicion should be its constancy. When a water supply is liable to pollution and hence requires treatment only one bacteriological standard is permissible, i.e., that the water should be as nearly as possible sterile. There should be no lactose fermenters in 100 cc. and less than 5 colonies per cubic centimeter on agar (temperature not given). This standard is aimed at in the London supply and is easily attained with the aid of hypochlorite or chlorine in any moderately efficient filter or chemical precipitation plant. The author's definition of a suitable water supply is; "It is one which is free from objectionable mineral salts and which can be rendered clear and 'sterile' by a cheap process without acquiring a taste which is itself objectionable. A properly treated water is one which is comparable to distilled water in clarity and which has been rendered 'sterile.'" The function of a purification plant is simply to clarify the water to equal distilled water, the percentage reduction of bacteria being quite unimportant as hypochlorite or chlorine properly applied can be depended upon to deal with the bacterial life. To bring Thames water to the London standard Houston found that available chlorine might require to be detected for 5 hours after the addition of the dose.—*Geo. C. Bunker.*

Indicating and Recording Instruments. C. Francis Newton. Water and Water Eng. (London), **23**: 276, 441, December, 1921. (Cf. Proc. Inst. Wat. Eng. London, 1921.) The following instruments normally in use in water works are described: level indicators, difference in level indicators, pressure gages, flow indicators and recorders, and integrators.—*Geo. C. Bunker.*

Elbe Water Pollution. W. P. Dunbar. Gesundheits-Ingenieur, **44**: 81-7, 155–63, 165–168. Water and Water Eng. (London), **23**: 275, 429, November, 1921. The water supply of Hamburg normally consists of four parts of river water and one part of ground water. Wastes from chemical works have rendered the hardness and saltness of the river water excessive. To keep the water supply within prescribed limit of hardness and chloric acid content the wastes must be kept out of the river.—*Geo. C. Bunker.*

Bacillus Welchii in a Public Water Supply as a Cause of Intestinal Disease. Herbert B. Larner. Jour. Amer. Med. Assoc., **78**: 4, 276, January 28, 1922. As a result of 187 cases of intestinal disorder reported early in 1921 in Montclair, New Jersey, the local Board of Health issued a warning to boil the water taken from the water supply for drinking purposes. Montclair is furnished with filtered and chlorinated water from the Little Falls, New Jersey purification plants. Symptoms included fever, vomiting, diarrhea, intestinal fermentation and headache. B. welchii were found almost continuously in the water supply during January and February, 1921. Bacteriological examinations of specimens of faeces from sick persons showed an organism similar to,

if not identical with, the organism in the water supply. While the evidence was not sufficiently satisfactory to show that B. welchii caused the cases of intestinal disorder, the author states it is extremely significant that the cases in February, 1921, had many points in common with approximately 2000 cases of intestinal disease in January, 1918, during which outbreak large numbers of this organism were found in the water supply. The final conclusion of the author is that, until qualified medical experts have decided whether or not B. welchii is pathogenic, "we should be extremely cautious about accepting as potable a water which contains the organisms in any such quantities as they have been demonstrated in the water served to Montclair."—*Geo. C. Bunker.*

Is Water Chlorination Effective Against All Water-Borne Disease? EDITORIAL. Jour. Amer. Med. Assoc., **78**: 4, 283, January 28, 1922. A discussion of the questions raised by the preceding article in the same issue of this Journal. While chlorination of water supplies has been remarkably efficient in doing away with the dangers of water-borne typhoid, it is plain that dependence on the chlorine treatment of highly polluted waters is to some degree unjustifiable if spores of certain pathogenic organisms are so resistant to chlorine that large enough numbers survive to cause extensive outbreaks of intestinal disease. Preliminary purification should precede chlorination in the case of water supplies polluted with large amounts of sewage. If the spores of B. welchii or of some similar anaerobic organism can withstand chlorine treatment, it may be desirable to make tests for such organisms in addition to those for B. Coli. The significance of "stormy fermenters" in chlorinated water supplies is not known and it must not be "too readily assumed" that they are the cause of gastro-intestinal outbreaks. The pathogenicity of B. welchii has not been demonstrated conclusively by feeding experiments both on monkeys and on man himself.—*Geo. C. Bunker.*

Adsorption in Sand Filters. JOHN DON. Water and Water Eng. (London), **23**: 276, 448, December, 1921. (Cf. Proc. Inst. Wat. Eng. London, 1921). A discussion of the decrease of ammonia and organic matters in water filtered through slow sand filters is followed by laboratory experiments made to find out how far the granules of sand with their watery envelopes are able to assist in purifying water from dissolved materials. The author concludes from his experiments that a sand filter freshly prepared is capable of adsorbing fairly large amounts of ammonia and dissolved organic substances, and that this action takes place rapidly.—*Geo. C. Bunker.*

Detection of Fluorescein in Water. L. LOMBARD. (Procede de Recherche de la Fluoresceine dans ses Solutions tres Etendues). Bull. de la Societe Chimique de France, no. 29, 462, 1921. (Cf. Water and Water Eng. (London) 23, 276, 477.) Fluorescein may be detected in extremely dilute solutions by acidifying 30 cc. of the water with a few drops of sulphuric acid, or by hydrochloric acid free from chlorine, then shaking with ether sufficient to yield a layer of 3 mm. to 4 mm.; after the addition of a little ammonia, the mixture is again shaken; if fluorescein be present, the layer of ether shows green before a dark background. After standing, the fluorescein, more soluble in water than in ether, will tinge the surface of the water. By this method it is possible to detect one part in 200,000,000.—*Geo. C. Bunker.*

Acid Proof Coatings for Concrete Surfaces. Edward H. Berger. Concrete, 16: 6, 276, June, 1920. A discussion of acid proof coatings for concrete tanks in which solutions of alum, acids, alkalis, and other chemicals are stored. Bituminous paints may be used on rather smooth walls and when exposed to mineral acids of low concentration. For acids of the lower concentrations the kind of base is immaterial. Bituminous enamels may be used on both smooth and rough walls and when exposed to relatively strong acids. A priming solution is first applied, followed by the enamel. Bituminous mastics are used for floors and are of two kinds depending upon cold or hot application. Specifications for the various materials are given as well as directions for their application.—*Geo. C. Bunker.*

Water from Missouri River Advised to Increase St. Louis Supply. Edward E. Wall. Eng. News-Record, 88: 437, 1922. Additional water supply for St. Louis taken from the Missouri River 8 miles above St. Charles, Missouri, is recommended. The cost of the new works is estimated at $22,000,000 yielding 120,000,000 gallons daily in 1960. This project and the present one at Chain of Rocks will yield 240,000,000 gallons daily in 1960 for an estimated population of 1,500,000.—*Frank Bachmann (courtesy Chem. Abstracts).*

Interstate Water Supply Certification. Anonymous. Eng. News-Record, 88: 449 (1922). Of the 3102 sources of water supply of interstate carriers on records of the United States Public Health Service, 42 per cent were certified as satisfactory; 11 per cent provisionally; 5 per cent classed as polluted; and no rating for 42 per cent due to lack of personnel. The country is divided into 9 sanitary districts, each district being in charge of a sanitary engineer of the Service.—*Frank Bachmann (courtesy Chem. Abstracts).*

Broken Section of 36-inch Pipe Line Burned Out by Electric Torch Under 50 Feet of Water. William W. Brush. Eng. News-Record, 88: 346–8 (1922). A section of a 36 inch flexible-joint, cast iron pipe line conveying Catskill water from Brooklyn to Staten Island, New York was removed and replaced by means of a specially designed torch (Merritt and Chapman). The cutting of the pipe took place in 50 feet of water. The torch consists of a carbon electrode which is bored for the passage of cutting gas, the carbon being connected to one pole of a generator the other pole grounded through the water to the metal to be cut. Current required is about 350 amperes at 60–100 volts. The metal is volatilized by means of the cutting gas administered at the point of the arc. A cast steel sleeve made the joint where old and new pipe lengths met.—*Frank Bachmann.*

State May Not Dictate Pure Water Source. Anonymous. Eng. News-Record, 88: 409 (1922). According to a decision of the Court of Appeals (Prunell et al. vs. Maysville Water Company, 234 S. W., 967) the State Board of Health of Kentucky has power to require a water company in that State to stop supplying impure water, but has no power to dictate the means that shall be employed to provide pure water. The decision is broad in that it applies to the abatement of any nuisance that is a menace to health.—*Frank Bachmann (courtesy Chem. Abstracts).*

A $60,000,000 Addition to Boston District Water Supply. Joint Board. Eng. News-Record, **88**: 360–3 (1922). Report by the Joint Board recommends the construction of a tunnel to divert the flood flow of the Ware River to the Wachusett reservoir, thus providing an additional 33,000,000 gallons per day for the Boston Metropolitan District and the City of Worcester. The run-off above 1.2 section feet per square mile from Ware, Swift and Millers Rivers to be stored in a 410,000,000,000 gallons reservoir. Water supplies of other sections of the State are considered.—*Frank Bachmann* (*courtesy Chem. Abstracts*).

Revamping the Artesian Water Supply of Bryan, Ohio. A. H. SMITH Co. Eng. News-Record, **88**: 351 (1922). The water supply is obtained from 8 artesian wells connected to a 10 inch suction line 2100 feet long. Previous to 1921 the suction line was connected to the centrifugal pumps supplying the town by direct pressure. The installation of a 1,000,000-gallon reservoir gave a fire reserve and restored and steadied the flow of privately owned wells in the city. Of the 865 taps, 98 per cent are metered. Consumption is estimated at 100 gallons per capita.—*Frank Bachmann.*

An Interesting Water Works Decision. Editorial, Fire and Water Eng., 71:8, 330, February 22, 1922. Nebraska supreme court reverses decision of department of public works, and gives permit to city of Chadron. Waterworks system was completed before application for permit.—*A. W. Blohm.*

Parks Around Water Supplies and Filter Plants. Editorial, Fire and Water Eng., **71**: 11, 450, March 15, 1922. Plan of utilizing the grounds surrounding reservoirs, pumping stations, filter plants, etc., as public parks is gaining favor among patrons of water systems.—*A. W. Blohm.*

Forestation of Watersheds. Editorial, Fire and Water Eng., **71**: 13, 531, March 29, 1922. Proper forestation of watersheds considered important, where supply is taken from mountain streams, springs, etc. Study of proper trees to replace dead or decayed trees on watershed, a science with which waterworks superintendents should be familiar.—*A. W. Blohm.*

Some Facts About Residual Alum in Filtered Water. A. M. BUSWELL AND G. P. EDWARDS. Chem. and Met. Eng., **26**: 826–829, May 3, 1922. The laboratory of the State Water Survey Division, Ill., undertook in 1920 an investigation of the various reactions involved in water purification when alum is used as a coagulant. The investigation showed that pH determinations alone are not sufficient for determining the optimum conditions for precipitation of aluminum hydroxide. Over 20 filter plants in different parts of Illinois were visited in collecting the data. None of the chemical reactions of alum go to completion, as there are a number of reversible reactions, each of which depends for its final equilibrium upon all the others. Any secondary reaction which tends to remove a product of a primary reaction will increase the amount of the primary reaction in the direction of the formation of the removed product. A chart is given representing such complex systems, show-

ing the interdependence of these reactions. It also emphasizes that in each of these equilibria the hydrogen-ion plays a part. Three conditions might affect the relation between alum and alkalinity. The loss of CO_2 with the precipitation of $CaCO_3$ may cause a decrease in alkalinity, the addition of lime may cause a net decrease in alkalinity due to this same precipitation of $CaCO_3$, and the formation of colloidal alumina instead of the precipitate tends to offset the decrease in alkalinity. At 4 of the 19 plants studied the decrease in alkalinity corresponds to 8 mg. per liter per grain per gallon of alum used, at 9 plants the decrease was greater than the calculated, and at 6 plants the decrease was less. A table showing the amounts of residual alumina present in the raw and filtered water of these 19 cities is given. With a fairly wide range of pH value there is no case in which the alumina in the effluent reaches zero. In the diagrammatic representation of the chemical reactions given, $H+$, AlO_3H_2-, $Al(OH)_3$, $Al+++$ and $OH-$ form a cycle. The reactions may be made to take place in either direction depending on the concentrations employed. Points plotted with residual alum and pH values as coördinates indicated a minimum alumina at a pH of 6.—*John R. Baylis.*

On the Design of Rain-Gages. S. P. FERGUSON. Monthly Weather Review, **50**: 2, 82, February, 1922. The paper includes a statement of the essential characteristics of rain-gages approved by the British Meteorological Office, which are:

1. The stout brass turned ring terminating upwards in a knife-edge, exactly 5 or 8 inches in diameter, which forms the rim of the gauge.
2. The vertical cylinder 4 to 6 inches deep, extending from the rim to the upper edge of the funnel, which is intended to retain snow and hail, to prevent the outsplashing of rain which has fallen upon the funnel and to reduce to a minimum the risk of loss due to wind eddies.
3. An inner collecting vessel, which can be removed for measuring the fall without disturbing the body of the gauge. Taps for drawing off water are extremely objectionable.
4. Provision for a depth of at least 6 inches of the body to be firmly fixed in the ground.
5. Simplicity of construction and avoidance of the use of rivets.
6. Strength and durability.
7. A capacity of not less than 10 inches of rain for a daily gauge. Gauges for monthly readings should be larger according to the district in which they are to be used.

The above conditions, with the exception of that numbered (3), apply generally also to self-recording rain gauges, it being noted, however, that the diameter of the rim of modern British recording gauges is usually either 6, 8, or 11 inches. Condition (5) is most important, and the following further desiderata apply:

8. The scale values of the chart must conform accurately with the indications of the instrument.
9. It is desirable that the hour lines on the chart should be straight and not curved.

10. It is desirable that the scale value for rainfall should be not less than six times the natural scale, and that the drum should make a complete revolution in 24 hours.

11. Dial gauges, tipping-bucket, and electrical-recording rain gauges are not in general suited to modern requirements.

12. Should the mechanism of the gauge include an automatic syphon, the design and construction of the syphon require special care; the liability to failure of syphons is a serious drawback.

13. Space should be available inside the case of the instrument for the insertion of a small oil lamp or a night light to warm the gauge in frosty weather.

The writer's experience in New England and the West corroborates the foregoing conditions.—*Isador W. Mendelsohn.*

Disinfection Studies—The effect of temperature and hydrogen ion concentration upon the viability of B. coli and B. typhosus in water. Barnett Cohen. Jour. Bact., 7: 183–230, March, 1922. The mortality of bacteria in distilled or tap water is variable and coincident with insignificant pH variations. Controlling the pH by means of buffer solution stabilizes this variability. At constant pH the relative resistance of B. coli and B. typhosus decreases with rise in temperature from 0°: 10°: 20°: 30° in the ratio of 67: 51: 18: 8. At 20°C., B. typhosus possesses the greatest tolerance within a narrow zone of hydrogen ion concentration (pH 5.00 to pH 6.4). A slight increase in acidity beyond the zone results in conditions of maximum mortality. For B. coli the zone is wider and centers about absolute neutrality (pH 7.0). The mortality of bacteria whether by strong disinfectants or by milder agents follows the laws of logarithmic decline.

Bacteria do not begin to die off at a maximum rate, but the mortality increases to a maximum gradually, depending upon the pH and temperature. The lower the temperature and the less extreme the acidity or the alkalinity the greater is the duration of this period.

There is a wealth of data plotted in the form of curves which illustrate and make clear the fact that B. coli is much more resistant in any water than is B. typhosus.—*L. H. Enslow.*

Hydrogen Ions, Titration and the Buffer Index of Bacteriological Media. J. H. Brown. Jour. Bact., 6: 521–23, November, 1921. A hydrogen ion concentration determination alone will not reveal facts that titration in conjunction therewith, will.

For many purposes a knowledge of the buffer content of media is of equal import with that of the hydrogen ion concentration. The buffer content, described as the "buffer index," is the sum of the "reserve acidity" and "reserve alkalinity" between stated limits of hydrogen ion concentration. The term "reserve acidity" is defined as that amount of alkali required to change the H.I.C. from the initial reaction to a stated lesser H.I.C. (say pH 8.0). The "reserve alkalinity" is that amount of acid required to change the pH from the initial reaction to a stated greater H.I.C. (say pH 5.0). The "buffer index" (in this case B. I. of pH 8 to pH 5) is the sum of the

"reserve alkalinity" and "reserve acidity" each value being expressed in per cent of normal acid or alkali. Appended to the paper is a simple laboratory method of determining these values, and also a convenient form of record.—*L. H. Enslow.*

The Nature of Acid Water from Coal Mines and the Determination of Acidity. W. A. Selvid and W. C. Ratliff. Jour. Ind. and Eng. Chem., **14:** 125–28, February, 1922. Data given show the erroneous results obtained when attempting a titration of "free" acid in waters containing a considerable quantity of ferric-iron compounds. Results are always higher than the true acidity unless all ferric iron is reduced to ferrous iron prior to titration. A method is given whereby free-acid may be distinguished from acidity due to the hydrolysis of aluminum and iron salts and each estimated quantitatively by direct titration with fair accuracy. Ferric iron is reduced through addition of an excess of KI and later removing liberated iodine by adding a slight excess of sodium this sulphate just prior to titrating in the cold. The result gives true acidity nearly correct. Total acidity is determined through titration of a boiling sample and using phenolpthalein as indicator. Acids of hydrolysis are obtained by difference.—*L. H. Enslow.*

,**The Application of H-Ion Concentration Measurements to the Control of Industrial Processes.** Earl A. Keeler. Jour. Ind. and Eng. Chemistry, **14:** 395–397, May, 1922. A description of electrical equipment for making hydrogen-ion concentration measurements in industrial plants and elsewhere. It is suggested, among many other applications on a practical scale, that boilers should be equipped with such an instrument and that the recording of the hydrogen ion concentration of the water in the boilers or of the feed water be continuous. The economy of maintenance of a sufficiently acid-free water is stressed. At present the Leeds-Northrup Company has in operation an installation which automatically injects alkali into the boiler feed-water whenever the recording instrument indicates the water at the time to have too great a hydrogen ion concentration (acid content).

Although the water may react alkaline to erythrosine or methylorange solutions the carbon-dioxide content may be sufficiently high to make the water in reality acid or corrosive, thereby requiring added alkali to reduce the hydrogen ion content and create a less agressive boiler-water which will not attack the tubes so violently.—*L. H. Enslow.*

Control of Corrosion by De-aeration of Water. Frank N. Speller. Jour. of Franklin Institute, **193:** 515–42, April, 1922. A 27-page article on the subject of corrosion with special attention to corrosion of hot water pipes. The author discusses the various factors causing corrosion, the relation of the composition of the metal to corrosion, the rate of corrosion, protective coatings, etc. The solubility of oxygen in water under various conditions is discussed and the relation of oxygen to corrosion is pointed out. Various means for de-aerating are described, and both American and European practice is reviewed. The author recommends removal of a large portion of the oxygen by mechanical de-aeration, the last 10 per cent being removed by means of chemical de-aeration such as scrap iron or ferrous sulphate.—*A. M. Buswell.*

The City Bulletin, Columbus, Ohio, 7: April 15, 1922. Annual Report of the Division of Water, 1921. Operating records and financial data of the Division of Water are given. Water softening and purification works repairs included, re-surfacing of alum solution tanks and alum and soda ash dissolving tanks with a rich mortar, lining soda ash solution tanks with lead, reducing the speed of the lime conveyor to reduce breakage of gears, and placing heavy paddles in the lime solution tanks.—*G. C. Habermeyer.*

Further Experiments with Activated Sludge. E. Hannaford Richards and G. C. Sawyer. J. Soc. Chem. Ind., **41:** 62 T, 1922. In a previous paper (J. S. C. I., **39,** 177 T) the authors have compared the fertilizer value of various sewage sludges with that of activated sludge. The present paper deals with the nitrogen content of activated sludge as compared with other sludges, the availability of the nitrogen in activated sludge for plant food and the source of the high nitrogen content in activated sludge. The data include chemical analyses, bacterial counts and microscopic determinations of the number of protozoa. A relation was established between the number of protozoa and bacteria, and the high nitrogen in the activated sludge was attributed to synthetic living protein of the bodies of bacteria and protozoa. (See also Marshall's Microbiology, Third Edition, page 188, Abstractor's note.) Under certain conditions of aeration free ammonia and nitrates are synthesized into proteins, as contrasted with the formation of free ammonia and nitrates which is ordinarily observed in the activated sludge processes. In certain experiments practically all influent nitrogen was accounted for, while in others some nitrogen was lost. In no case was fixation of nitrogen observed.—*A. M. Buswell.*

Chemical and Biological Reaction in the Dorr-Peck Tank. A. M. Buswell, A. A. Brensky, and S. L. Neave. Amer. Jour. of Pub. Health, **12:** 299. Reports chemical data on the nitrogen cycle in the activated sludge process operating with low air, together with data on the performance of Dorr-Peck tank. With the low amounts of air used the action of the nitrifying organisms was reversed so that nitrates and ammonia were synthesized into protein. The nitrogen balanced showed that all nitrogen was accounted for within the limits of experimental error and that under the conditions of the experiment there was neither loss nor fixation of nitrogen. Attention is called to the lack of correlation between the volume and weight of activated sludge. The performance of the Dorr-Peck tank as designed for this experiment was not satisfactory and the apparatus has been withdrawn by the manufacturers.—*A. M. Buswell.*

Removing Boiler Scale with CO_2. R. J. Cross and Roy Irvin. Power, **55:** 422, March 14, 1922. A method is given for the laboratory treatment of boiler scales, high in lime and silica and comparatively low in carbonate, with carbonated water. Experiments were also made with horizontal return tubular boilers in which a hard and very adherent scale had accumulated during several years. A mixture of 100 lbs. of sal soda and 70 lbs. of lye per boiler did not remove the scale. One boiler was filled with boiled water free from dissolved gases and 3 cylinders or 150 lbs. of carbon dioxide were discharged

into it. The temperature of the water was 84°F. After standing 8 days 287 lbs. of softened scale were removed. Almost half the surface of the boiler was free from scale and rust, and the exposed surface had the blue color of new tubes. A year later the treatment was repeated and more than 100 pounds of scale were removed, after which the boiler was practically free from scale. No cost figures are given.—*Geo. C. Bunker.*

The Point of Release on the Indicator Diagram. Power, 55: 424, March 14, 1922. Complete expansion can not be secured. Exhaust valves should open before the end of the stroke. No practical loss of energy occurs with early release.—*Geo. C. Bunker.*

Practical Information about Injectors. TERRELL CROFT. Power, 55: 460, March 21, 1922. How the different types work; advantages and disadvantages; applications; testing; selection; how to overcome operating troubles.—*Geo. C. Bunker.*

Reasons for the Peculiar Shapes of the Back Pressure Line of the Indicator Diagram. Power, 55: 464, March 21, 1922. Effect of decreased back pressure. —*Geo. C. Bunker.*

Why Complete Compression is Not Economical. Power, 55: 496, March 28, 1922. A discussion of the compression line on the indicator diagram, showing that compression to the initial pressure is not efficient. Description of a graphical method of finding proper compression for any given cutoff.—*Geo. C. Bunker.*

Reasons for Distorted Admission Lines on Indicator Diagrams. Power, 55: 538, April 4, 1922. Discusses the subject of lead and by typical diagrams shows the engineer the manner of admission line to avoid.—*Geo. C. Bunker.*

A Simple Test for Measuring Surface-Condenser Leakage. O. P. ADAMS AND P. F. HOOTS. Power, 55: 540, April 4, 1922. By the determination of chlorides in the hot well, returns, the cooling water, and in a condensate from the steam line, the percentage leakage of the condenser may be calculated.—*Geo. C. Bunker.*

Maintenance and Inspection of Storage Batteries. CHESTER SCHENCK. Power, 55: 571, April 11, 1922. Outline of inspection system; indications of short-circuits, sulphating and buckling and the remedies; treatment of weakened cells.—*Geo. C. Bunker.*

Indicator Diagrams. Power, 55: 574, April 11, 1922. Twenty-eight examples from Corliss, Una-Flow, and Non-Releasing Four Valve Engines.—*Geo. C. Bunker.*

Largest Station Using Pulverized Coal. Power, 55: 604, April 18, 1922. The Lakeside station of the Milwaukee Electric Railway and Light Co. Laid out for 200,000 kw. of which 40,000 kw. is installed.—*Geo. C. Bunker.*

How to Make Forms for Concrete Buildings—Columns. W. F. Lockhardt. Concrete, **20:** 164, April, 1922. The third article of a practical series written for builders. The first article (February) was on Footings; the second (March) on Walls.—*Geo. C. Bunker.*

Hard Water and Health. Water and Water Eng. (London), **24:**82, March 20, 1922. Abstract of paper by Lincolne Sutton on water supplies of Norfolk and Suffolk. The hardness of Norfolk waters varies from 12 to 20 degrees (Clark) or 171 to 286 p.p.m. Norfolk has had an unenviable reputation for the prevalence of calculus for a long time, but the author takes the view that it can not be attributed to the local waters, and his conclusion is that: "In all probability, hard water is better for our young growing people, who require lime salt for the healthy development of their bones and teeth. Soft water may suit the aged, who, however, drink less with advancing years. To the average adult it is a matter of indifference."—*Geo. C. Bunker.*

Jerusalem New Water Supply. F. W. Stephen. Royal Engineers Jour., December, 1921, pages 261–8. Abstract; Water and Water Eng. (London), **24:** 107, March 20, 1922. Describes water supply as found on occupation by British Army and additions made to enlarge it.—*Geo. C. Bunker.*

Supply of Drinking Water in Belgium. A. Mennes. Water en Gas. January 6, 1922, pages 4–5. Abstract; Water and Water Eng. (London), **24:** 108, March 20, 1922. A review of the administrative and technical aspects of the supply of drinking water in Belgium.—*Geo. C. Bunker.*

The Provincial Supply of Drinking Water for North Holland. B. F. van Nievelt. Water en Gas. January 6, 1922, pages 2–3. Abstract; Water and Water Eng. (London), **24:** 108, March 20, 1922. A choice had to be made between the system by which the water works enterprise acts as a wholesale supplier, leaving the distribution and fixing of tariffs to the local authority, and that by which it delivers directly to the inhabitants without any interference by the local administration. It was resolved to supply no district unless the local authorities made a by-law for the compulsory use of water from the mains in any house distant not more than 40 meters from the centre of the road in which there was a water main, except in cases where a good and sufficient supply was already at hand.—*Geo. C. Bunker.*

Condition and Behavior of Core Material in Hydraulic Fill Dams. C. H. Paul. Proc. Am. Soc. C. E., **48:** 452–72, 1922. Eng. Cont., **57:** 353. The construction of 5 dams on the Miami Conservancy project has shown

1. Gradation of core material may be controlled.
2. Excess of fines is required in borrowpit material, to control core and prevent encroachment of gravel and sand.
3. A reasonably wide core, (width at any point equal to height of dam above that point) is necessary.
4. A high percent of fine material in core is not objectionable, if properly graded.

5. Such cores show a satisfactory rate of consolidation.
6. Such cores are stable, after a few months of consolidation, in that they do not flow when outside slope material is removed.

Extended details are given on studies of design and construction.—*Langdon Pearse* (*Courtesy Chemical Abstracts*).

Proposed Reservoir for Boston's Water Supply. X. H. Goodnough. Rept. Joint Board, 1922, Pub. Works, 52: 287–8. The report recommends construction of a reservoir 17 miles long, 4 miles wide, storing water of Swift, Ware and Miller Rivers, at a cost of $60,000,000.—*Langdon Pearse* (*Courtesy Chemical Abstracts*).

A Comparison of the Hardness of Public Water Supplies in Massachusetts, New York and New Jersey. W. S. Coulter. Mun. Cty. Eng., 62: 109–12, 1922. The average hardness found in parts per million is in Mass. surface water 18.2, ground 27.3; in N. J. surface 32.8, ground 64.1; in N. Y. surface 64.3, ground 155.—*Langdon Pearse* (*Courtesy Chemical Abstracts*).

Design and Construction of Novel Concrete Conduit. W. A. Kunigh. Eng. Cont., 57: 347–351, 1922. A semi-circular conduit, 36 in. diam. with flat top, was built at Tacoma in 1921 with gunite, with a thickness of 3 in. No expansion joints are provided. The mix was 1: 3 cement and sand. The excavation was cut to line and grade and then backfilled and tamped to the outside line of the invert. The top was made by precasting a reinforced slab which was then used as a base for the gunite. The cost per lineal foot was $7.07. The plant and organization are detailed.—*Langdon Pearse* (*Courtesy Chemical Abstracts*).

Cleaning Irrigation Canals with Modified Disc Harrows. H. L. Crawford. U. S. Reclamation Rec., February, 1922. Eng. Cont., 57: 357–8, 1922. Modified disc harrow with 20-inch discs is very successful in removing moss from irrigation ditches. A team on each bank pulls the machine. The number of discs varies.—*Langdon Pearse* (*Courtesy Chemical Abstracts*).

Cost of Water Main Construction at Hartford, Conn. Ann. Rep. Bd. Water Comm., March 1, 1921. Eng. Cont., 57: 346, 1922. Comparative costs are given for 4 to 16 inch pipe for years 1915 to 1920.—*Langdon Pearse* (*Courtesy Chemical Abstracts*).

Cost of Water Main Construction, Water Meter Installation and Testing at Detroit. Report Bd. Water Commr., 1921. Eng. Cont., 57: 346, 1922. Costs of material, labor and expense are given for 2 to 48 in. pipe laid in 1920–21. For 6- and 8-inch cost was $2.63 and $3.67 respectively. The cost of installing meters ($\frac{5}{8}$ to 4 inches) is given, for $\frac{5}{8}$- and $\frac{3}{4}$-inch being respectively $7.80 and $10.68. The cost of meter testing is also given.—*Langdon Pearse* (*Courtesy Chemical Abstracts*).

Cost of Repairing Meters at Los Angeles. Report Bd. Pub. Service Comm., 1921. Eng. Cont., **57**: 346, 1922. Details of costs of meter repair are given from $\frac{5}{8}$ to 6 in. Average cost for $\frac{5}{8}$ and $\frac{3}{4}$ in. meters was $1.51 and $2.01.—*Langdon Pearse* (*Courtesy Chemical Abstracts*).

Gilboa Dam Construction. Pub. Wks., **52**: 205–8, 1922. The exploration borings, pressure tests, river diversion, foundations, excavations and contractor's plant are described.—*Langdon Pearse* (*Courtesy Chemical Abstracts*).

Scoring Water and Sewage Treatment Works. F. E. Daniels. Pub. Wks., **52**: 135–8, 1922. Blank forms are shown for scoring plants.—*Langdon Pearse* (*Courtesy Chemical Abstracts*).

Constructing Detroit Filter Plant. Pub. Wks., **52**: 77–8, 1922. This is a description of contracting plant, for a rapid filter occupying an area of 500 x 800 feet. Two cableways were used. A central concrete mixing plant was provided.—*Langdon Pearse* (*Courtesy Chemical Abstracts*).

Typhoid Fever in Detroit. F. M. Meader. Pub. Wks., **52**: 78, 1922. Of 247 cases in four summer months in 1921, 43 were traceable to bathing in the Detroit River.—*Langdon Pearse* (*Courtesy Chemical Abstracts*).

Typhoid Fever Record at Lawrence, Mass. Pub. Wks., **52**: 62–3, 1922. The typhoid rate in this city of 100,000 has decreased, since installation of filters until in 1921 there were only 20 cases and one death.—*Langdon Pearse* (*Courtesy Chemical Abstracts*).

Sensitive Detection of Suspended Matter. J. R. Baylis. Pub. Wks., **52**: 6–7, 1922. A ray of light is passed through a 3-liter flask at right angles to the line of sight. The flask and light are enclosed. The device is very sensitive in a qualitative way.—*Langdon Pearse* (*Courtesy Chemical Abstracts*).

Western Avenue Tunnel Extension. Pub. Wks. **52**: 1–4, 1922. A tunnel 11 feet 4 inches wide by 12 feet high inside, is being driven 33,000 feet in solid rock. The capacity is estimated at 800,000,000 gallons per twenty-four hours. The average force employed in 4 headings is 400 men. The cost will be about $4,000,000. The details of construction and plant are described. The rock is crushed and screened in a traveling apparatus. The concrete is mixed and distributed by pneumatic pressure.—*Langdon Pearse* (*Courtesy Chemical Abstracts*.)

Wood Stave Water Pipe. U. S. Reclamation Record, December, 1921. Pub. Wks., **52**: 5, 1922. This is a summary of a questionnaire sent out by the Reclamation service, covering 196 installations. The data indicate life of pipe is shortened by intermittent service, alkali soil (destroying steel bands), separate wooden collars at joints, low heads. Wire wound fir does not last as well as redwood.—*Langdon Pearse* (*Courtesy Chemical Abstracts*).

The Organization of Metropolitan Districts. LANGDON PEARSE. Am. Soc. Mun. Impvt. 1921. Can. Eng., **42**: 227–30, 1922. Pub. Wks., **52**: 12–13, 1922. A summary describing various metropolitan districts, organized for sanitary purposes, chiefly for sewerage or sewage treatment. Purposes, powers, and limitations are detailed.—*Langdon Pearse* (*Courtesy Chemical Abstracts*).

The Heat of Coagulation of Ferric Oxide Hydrosol with Electrolytes. F. L. BROWNE AND J. H. MATHEWS. J. Amer. Chem. Soc., **43**: 2336–52, 1921. From Chem. Abst., **16**: 517, February 20, 1922. The heats of coagulation of Graham's ferric oxide hydrosol vary greatly with the nature of the electrolyte used, but in each case it becomes less as the hydrosol is further purified by dialysis. The heat effect on mixing dilute ferric chloride solutions with these electrolytes is sufficient to account for the thermal effects observed.—*R. E. Thompson.*

A Note on Colloidal Selenium. A. GUTBIER AND R. EMSLANDER. Ber. 54B, 1974–1978, 1921. From Chem. Abst., **16**: 517. February 20, 1922. The stability of colloidal selenium was found to be a function of the degree of dispersion. The more dilute the colloid the higher its dispersion and the longer the time required to coagulate it. On addition of certain electrolytes the yellow colloid became successively red, violet and blue, indicating a growth in the size of the particles. The addition of very small amounts of such substances as hydrochloric acid, sodium carbonate and potassium chloride, stabilized the colloid and prevented coagulation by freezing. Higher concentrations of these salts are efficient coagulants of this same colloid.—*R. E. Thompson.*

Colloidal Condition of Substances Slightly Soluble in Water and Other Solvents. I. TRAUBE AND P. KLEIN. Kolloid-Z., **29**: 236–46, 1921. From Chem. Abst., **16**: 518, February 20, 1922. By means of Tyndall cones and the ultramicroscope it has been shown that many difficultly soluble organic and inorganic substances are dissolved wholly or partly as colloids. It is pointed out that the colloidal nature of many poisons calls for experiments on the adsorption of these substances on the surfaces of blood corpuscles, yeast cells, bacteria, etc., as well as on the taking up of the poison within the cell.—*R. E. Thompson.*

A Very Sensitive Test for Copper: The Reaction of Kastel-Meyer. P. THOMAS AND G. CARPENTIER. Compt. rend., **173**: 1082–5, 1921. From Chem. Abst., **16**: 538, February 20, 1922. A solution of 2 grams of phenolphthalein and 20 gms. of pure potassium hydroxide in 100 cc. pure water will give a pink coloration with a solution containing 1 part of copper in 100,000,000 parts of water. The reaction may be used for the colorimetric determination of copper in water.—*R. E. Thompson.*

Volumetric Determination of Aluminium. E. J. KRAUS. Chem.-Ztg., **45**: 1173, 1921. From Chem. Abst., **16**: 539, February 20, 1922. A volumetric method for the determination of aluminium is outlined as follows: Dissolve the precipitate of aluminium hydroxide in dilute sulphuric acid, render neutral

and titrate with standard disodium hydrogen phosphate in the presence of a few drops of silver nitrate. The aluminium is precipitated as aluminium phosphate and the completion of the reaction is indicated by the formation of a yellow precipitate of silver phosphate.—*R. E. Thompson.*

The Probability of Effusion of Colloid Particles and Related Ideas. E. Buchwald. Ann. Physik, **66**: 1–24, 1921. From Chem. Abst., **16**: 515–6, February 20, 1922. The probability that a colloid particle originally in the finite volume, v, of a sol shall after a lapse of time no longer remain in v, was determined for different time intervals in the case of a selenium hydrosol. Smoluchowski's theory was in general confirmed, but a small systematic variation was observed.—*R. E. Thompson.*

Precipitation of Colloids by Nonconductors. P. Klein. Kolloid-Z., **29**: 247–50, 1921. From Chem. Abst., **16**: 516, February 20, 1922. Nonconductors, such as isoamyl alcohol, heptyl alcohol, chloroform, carbon tetrachloride, benzene, etc., caused the precipitation of negative colloids without the aid of electrolytes. The precipitating agent was dissolved in ethyl alcohol in order to obtain the finest possible sub-division. Electropositive sols, such as ferric hydroxide and aluminium hydroxide, were not precipitated.—*R. E. Thompson.*

Quantitative Methods for Coagulation of Suspensoids. F.-V. v. Hahn. Kolloid-Z., **29**: 226–36, 1921. From Chem. Abst., **16**: 516, February 20, 1922. The methods based on the precipitation of the colloid by an electrolyte were tested, and other methods developed. Exhaustive experiments showed that coagulation by boiling is probably due to an adsorption process at the surface between vapor and liquid.—*R. E. Thompson.*

The Protective and Flocculating Action of Hydrophilic Colloids and Hydrophobic Sols. H. Freundlich and E. Loening. Festschrift Kaiser Wilhelm Ges. Förderung Wiss. Zehnjahrigen Jubiläum 1921, 82–89. From Chem. Abst., **16**: 516, February 20, 1922. It was shown by experiments with both gold and silver sols, that the sensitization of a hydrophobic sol by a hydrophilic colloid is merely a coagulation which is too slight to become immediately observable. It can be detected only by the fact that when the sol is thus sensitized, smaller amounts of electrolytes are required for flocculation. The transition from coagulation to protective action observed by Gann is a general phenomenon, and is probably dependent on the fact that the oppositely charged hydrophilic sol in low concentration coagulates the particles of the hydrophobic sol, whereas in higher concentration the former actually envelops and thus protects them.—*R. E. Thompson.*

Value of Flue Gas Analysis. A. B. Helbig. Feuerungstechnik, **9**: 229–34, 1921. From Chem. Abst., **16**: 634, February 20, 1922. A formula is developed by means of which the heating value of the coal can be calculated from the analysis of the flue gases.—*R. E. Thompson.*

Effect of Sea Water on Concrete Structures. C. E. W. DODWELL. Cement Eng. News, **33**: 29–30, 1921. From Chem. Abst. **16**: 624, February 20, 1922. A brief report on the experience with concrete piers at Annapolis Royal, N. S. Most of the disintegration was due to freezing and the abrasive action of floating ice.—*R. E. Thompson.*

Boiler Plant Efficiency. V. J. AZBE. Mech. Eng. **43**: 722–4, 726, 1921. From Chem. Abst. **16**: 633, February 20, 1922. Ninety per cent efficiency (representing boiler and economizer only) is attainable under favorable conditions, but the requirements are severe. With 12000 B. t. u. coal, 15 per cent excess air would have to be used, flue-gas temperature would have to be not more than 250°F., combustion complete, and no carbon in the ash. The requirements of the ideal boiler installation of today are summarized.—*R. E. Thompson.*

Determination of the Carbon Dioxide Content of Flue Gases from the Firing of Steam Boilers. H. WINKELMANN. Braunkohle **20**: 307–310, 326–329, 1921. From Chem. Abst. **16**: 635, February 20, 1922. The important theoretical principles of combustion and the various methods of determining carbon dioxide in flue gases are dealt with.—*R. E. Thompson.*

Report on Water. J. W. SALE. J. Assoc. Official Agr. Chem., **5**: 29–32, 1921; cf. C. A. 15, 2139. From Chem. Abst. **16**: 453, February 10, 1922. The average error in the results obtained by the tentative method for the determination of bromine in presence of chlorine and iodine was found to be 5.6 per cent. Determination of nitrates in water by addition of dilute phenoldisulphonic acid to the sample before evaporation and omitting the removal of chlorine with silver sulphate was found to be unsatisfactory.—*R. E. Thompson.*

Annual Report of The Copenhagen Waterworks for the Year 1910–1911. Anon. Pub. Health Eng. Absts., December 10, 1921. From Chem. Absts., **16**: 453, February 10, 1922. Ninety-seven per cent of the supply is derived from wells, and the average daily consumption is 117 liters per capita. The works consist of two filter plants of 9 and 3 units respectively, and two aerating stations for the oxidation of iron.—*R. E. Thompson.*

Further Studies on the Application of Ozone to the Purification of Swimming Pools. W. A. MANHEIMER. Med. Record, **100**: 851–2, 1921. Pub. Health Eng. Absts., December 10, 1921. From Chem. Abst. **16**: 455, February 10, 1922. From a series of tests with ozone for purifying swimming pool waters at the U. S. Military Academy and public institutions in Cleveland and Lincoln, Nebraska, the treatment is considered satisfactory.—*R. E. Thompson.*

Determination of Sulfurous Acid. V. COPPETTI. Ann. chim. anal. chim. appl., **3**: 327–30, 1921. From Chem. Abst., **16**: 540, February 20, 1922. An apparatus, designed to prevent the loss of iodine in the Haas method of determining sulfurous acid, is described. The apparatus consists of a 300-cc. flask connected by ground-glass stopper to upper chambers which serve as a con-

denser and as receptacles for iodine and sodium thiosulfate solutions. The sulfur dioxide is expelled from the solution under examination by a stream of carbon dioxide and is absorbed by iodine solution in one of the upper chambers, any iodine carried off by the current of gas being collected in the second chamber containing sodium thiosulfate. When the operation is complete the contents of both chambers are mixed and the excess iodine determined by titration.—*R. E. Thompson.*

Water of Borax Lake. R. C. WELLS. J. Wash. Acad. Sci., **11**: 477–81, 1921. From Chem. Abst., **16**: 543–544, February 20, 1922. Recent analyses indicate that the water of Borax Lake has changed in composition. "In order to represent the dissolved alkaline matter in the form of the customary buffer salts an artificial water, containing 18.5 grams sodium chloride, 0.5 magnesium chloride, 1.0 potassium chloride, and 0.03 calcium sulphate per liter, was made up as a medium to which buffer salts could be added and the resulting pH values determined. A set of pH determinations were then made with various proportions of sodium carbonate and sodium bicarbonate; the total carbon dioxide was kept equal to that found in the lake water. Another similar set was made with mixtures of borax and sodium metaborate; the total B_2O_3 was kept the same as found in the lake water." The pH value of the water was 9.75. To yield this figure the salts should be distributed, in grams per liter, as follows: sodium carbonate 5.9, sodium bicarbonate 3.5, sodium metaborate 2.17, borax 0.68. These findings are compared with those of Searles Lake brine in which pH equals 9.48.—*R. E. Thompson.*

The Water Supply of The Egyptian Expeditionary Force, with Special Reference to the Efficiency of Mechanical Rapid Filtration with Chlorination. R. J. S. McDOWELL. J. Hyg., **19**: 305–8, 1921. From Chem. Abst., **16**: 601, February 20, 1922. A physiological experiment on a large scale proved that rapid filtration and chlorination methods of treatment can render an initially highly polluted and dangerous water safe for human consumption.—*R. E. Thompson.*

The Determination of Phosphate in Waters. D. FLORENTINE. Ann. chim. anal. chim. appl., **3**: 295–296, 1921. From Chem. Abst., **16**: 601, February 20, 1922. The phosphorous pentoxide content of a stream of water may indicate pollution. The following modification of Deniges method has been found satisfactory for quantities of 0.01–5 p.p.m. Two reagents are required, (1) 100 cc. of 10 per cent ammonium molybdate mixed with 300 cc. of 50 per cent sulphuric acid. (2) 0.1 gram of tin dissolved in 2 cc. of pure hydrochloric acid containing a trace of copper salt, and diluted to 10 cc. Procedure: To 10 cc. of the water add 3 to 4 drops of reagent (1) and 1 drop of reagent (2) (or 3 drops for quantities greater than 2 p.p.m. Allow to stand 10 minutes and compare the blue color produced with standards containing known amounts of phosphates. More permanent standards can be prepared from an organic dyestuff such as indigo carmine. Orthoarsenic acid is the only substance that has been found to interfere with the test. Larger quantities of phosphates should be determined by precipation as ammonium phosphomolybdate, using 10 cc. of a 10 per cent nitric acid solution of ammonium molybdate for 25 cc. of water.—*R. E. Thompson.*

Iron Bacteria in Relation to the Incrustation of Pipes. D. Ellis. Engineering, **112**: 457–458, 1921. From Chem. Abst., **16**: 601–602,Fe bruary 20, 1922. Five species of iron bacteria, Leptothrix ochracea, Gallionella ferruginea, Cladothrix dichotoma, Crenothrix polyspora, and Spirophyllum ferrugineum cause iron troubles. These bacteria are saprophytes and require organic matter and certain mineral ingredients (iron is not essential) for favorable growth. Acid waters are more favorable than alkaline waters, a reduction in acidity diminishing the power of the bacteria to harm. These growths are classified as (1) slimy streamers, (2) tubercular incrustations, (3) iron incrustations, and (4) spongy disease of cast iron, and each is discussed separately, giving causes and remedies.—*R. E. Thompson.*

Physical Chemical Study of the Absorbent Power of Soils. Luigi Casale. Staz. sper. agrar. ital., **54**: 65–113, 1921. From Chem. Abst., **16**: 604, February 20, 1922. This is a detailed discussion of the absorbent powers of soils, based on the fact that the conditions controlling absorption by soils are identical with those governing absorption by colloids.—*R. E. Thompson.*

Hard Pan in the Apulian Soils and Its Origin. A. de Dominicis. Ann. scuola agr. Portici, **15**: 1–39, 1919. Bull. Agr. Intelligence, **11**: 292–293, 1920. From Chem. Abst., **16**: 606, February 20, 1922. The position of the hard pan is indicated by the layer where the capillary water meets the solution running through the soil, its formation being due to the reactions taking place when the two waters mix. These reactions are similar to the coagulations which take place through the action of electrolytes upon hydrosols, the latter occurring as colloidal substances in the circulating water, while dissolved calcium carbonate serves as an electrolyte in the capillary water.—*R. E. Thompson.*

Portland Cement—Its Testing and Specification. R. E. Stradling. Concrete and Constr. Eng., **16**: 169–177, 223–233, 1921. From Chem. Abst., **16**: 623, February 20, 1922. The essential properties of cement as an engineering material are: setting time within workable limits, soundness, and strength sufficient for requirements. When cement is mixed with water a considerable portion usually does not hydrate thus causing waste. The hydration is apparently affected by (1) fineness of grinding, (2) manner and amount of mixing, (3) amount of water used, and (4) temperature of water used.—*R. E. Thompson.*

Protecting Reinforced Concrete from Marine Deterioration. F. E. Wentworth-Shields. Engineering, **112**: 73, 1921. From Chem. Abst., **16**: 624, February 20, 1922. The types of failure in marine structures are discussed and the various methods of preventing deterioration due to sea water reviewed, including rendering the concrete highly impermeable, integral mixtures, and surface coatings.—*R. E. Thompson.*

Deterioration of Reinforced Concrete Structures above Mean Tide Level. L. H. Savile. Engineering, **112**: 73–74, 1921. From Chem. Abst., **16**: 624,

February 20, 1922. This subject is briefly discussed and a number of possible explanations of phenomenon advanced. The concrete below water level remains saturated with water and any dissolved oxygen removed by oxidation is not easily replaced. The water probably becomes very slightly alkaline, which would account for the non-appearance of rust below the line of saturation.—*R. E. Thompson.*

Waterproofing Concrete by Hydrated Lime Process. B. Nagy. Cement Eng. News, **33**: 27–28, 1921. From Chem. Abst., **16**: 624, February 20, 1922. The permeability of concrete, and the necessary characteristics of a material for use in decreasing the permeability are discussed. Hydrated lime possesses these characteristics.—*R. E. Thompson.*

External Corrosion of Mains and Services. J. G. Taplay. Gas J., **156**: 210–211, 1921. From Chem. Abst., **16**: 635–636. February 20, 1922. In built-up ground, acid in character and containing decayed vegetable matter, dextrose, ferrous acetate, calcium acetate, calcium formate, calcium nitrate, and calcium nitrite, corrosion was due to bacterial action with the formation of acetic acid. Corrosion of pipes laid in alkaline soils or in plaster walls was caused by calcium bicarbonate and water. The latter reaction is dealt with in detail. —*R. E. Thompson.*

The Chlorination of Small Water Supplies. F. B. Jones. Canadian Medical Assoc. J., **11**: 908–910, December, 1921. Chlorination, although considered by the author to be only a more or less temporary means of purification, was found effective in eliminating the colon-typhoid group of bacteria from water. The use of galvanized pipe and fittings, and the application of a good mineral or asphaltum paint to wooden barrels materially assists in reducing corrosion due to hypochlorite solutions to a minimum. A special drip nozzle, by means of which the application of hypochlorite solution can be accurately controlled, is described in detail. The following procedure is recommended for the disinfection of wells. Apply a solution of calcium hypochlorite in the proportion of 1 pound of hypochlorite to every 332.6 cubic feet of water contained in the well (5 parts per million of available chlorine), allow to stand 24 hours and then pump dry.—*R. E. Thompson.*

The Bradford Water Supply. L. Mitchell. Surveyor, **61**: 43–45, January 20, 1922 and **61**: 133–135, February 3, 1922. The water supply of Bradford (England) is described in detail. The comparative softness (2.5 deg.) of the supply is of great economic importance to the community. For domestic use, in addition to the saving in soap, there is also a considerable reduction in the amount of tea required. From a commercial point of view the greatest advantage is, of course, the absence of scale in boilers, $\frac{1}{8}$ inch of scale necessitating the use of 16 per cent more fuel, $\frac{1}{4}$ inch 50 per cent and $\frac{1}{2}$ inch 150 per cent. The filters in use are of the ordinary slow-sand type, but the author states that the results obtained from mechanical or pressure filters, introduced in England from America, are practically identical with those from the best slow-sand filters. The daily consumption is 18,000,000 gallons (supplying a

population approaching 400,000), this amount corresponding to a per capita consumption of 46 gallons as compared with the average of 35 gallons for the principal cities in Great Britain. The installation of a house meter system is considered impracticable owing to the amount of capital involved and to the cost of inspection and repairs.—*R. E. Thompson.*

Statistical Record of Toronto Water. Laboratory observations recorded during a ten-year period of purification, 1912–1921. Norman J. Howard. Canadian Engineer, 42:19, May 9, 1922. Brief résumé of water purification in chronological order is given. Extensive nature of the laboratory work carried out in Toronto is described in detail. During 1921 no less than 21,028 samples were examined. Methods of analysis as recommended by the American Public Health Association are criticised, tests for the isolation of the colon bacillus having been found particularly inconclusive and unsatisfactory. Addition of 0.5 per cent of sodium taurocholeate to lactose broth is suggested as being not too inhibitory and particularly favourable to the propagation of the colon group. Attention is directed to the incomplete reports frequently issued by laboratories, which it is claimed are often misleading due to lack of details and incompleted tests. The system of application of alum and chlorine to the water is given, aluminium sulphate being added for clarification purposes while chlorine is added both before and after filtration. Bacteriological figures show pollution of raw Lake Ontario water to have yearly increased, following the normal increase of population and industrial development, and attention is directed to this condition applying generally throughout the American continent. Reasons given are the discharge of untreated sewage and industrial wastes into the Lake, and the expressed desire of municipalities to withold spending large sums of money on disposal works pending the further development of sewage purification. The effect of pollution on the efficiencies of the filtration plants is shown in the tables, the slow sand plant giving an effluent purer than the water from the mechanical plant. Residual alum is found in the mechanically filtered water in colloidal form, which produces after precipitation, has shown no evidence of protecting bacteria against the sterilising effect of chlorine and is regarded as being of no sanitary significance. It is assumed that the hydrogen ion concentration of the water is particularly favourable to this condition, the after precipitation of alum experienced in some instances being due to the pH being below 6.8. Filter operation is briefly touched upon, attention being directed to the practice of raking the surface of the slow sand filters to increase the length of run, which custom is apparently prohibited in Europe. When the raw water is physically good, chlorine is applied to the mechanical plant prior to filtration instead of alum. By doing this an actual saving of $35,000 was made in 1921 and purer water obtained. Considerable space is given to bacterial concentration and its relationship to seasonal efficiency of the plants. The greatest concentration is found to occur in the summer months when the slow sand plant produces the greatest efficiency, and the mechanical plant gives the lowest purification. Biological activity is claimed to control the slow sand purification. The writer claims that the lower efficiencies obtained in the mechanical plant during the summer months, is not controlled by variations of the hydrogen ions but is due to great bacterial concentration and

organic colloids. Application of chlorine shows that nearly twice as much is used in the warm weather when the water temperature rises. Taste occurring in the early spring and fall is attributed to the formation of chlorophenols, and the lack of taste in the summer months to increased biological activity which is claimed to prevent the formation of certain chemical compounds. During the past twelve years since the treatment of the water began, a remarkable decline in typhoid fever has occurred, the rate falling from 40.8 in 1910 to 3.0 in 1921. This is attributed to filtration and final sterilisation of the water supply.—*Norman J. Howard.*

Chlorination, Tastes and Odors. Editorial. Canadian Engineer, **42**:18, May 2, 1922. One of chief problems sanitarians are called upon to investigate is occurrence of taste and odor in water. Taste resulting from excessive algae growths are not common in Canada, because storage and impounding reservoirs are not extensively used. Chief problem is taste following application of chlorine for sterilisation purposes, which is attributed to formation of chloro-phenols following the discharge of industrial wastes into streams from which public supplies are drawn. Assuming that this is the cause, legislation should be framed to prevent the indiscriminate discharge of effluents into sewerage systems. It is likely that many industrial plants could recover by-products from their trade wastes which would not only compensate them for labor and expense involved, but might actually be instrumental in preventing taste in water treated with chlorine. It may be found that when taste occurs from chloro-phenols, there are definite quantities of each reagent which combine and cause taste, and that a decrease or increase of chlorine may be the solution. With so many of the leading chemists working on the problem, a solution to the question is anticipated at an early date. —*Norman J. Howard.*

Correction: On p. 533, May, 1922, Abstracts section, read "Iowa" for "Ohio" under "Rules and Regulations."—*Ed.*